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Iwasaki

(10) **Patent No.: US 9,491,352 B2**
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(54) **IMAGING DEVICE, SIGNAL PROCESSING METHOD, AND SIGNAL PROCESSING PROGRAM**

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(30) **Foreign Application Priority Data**

Mar. 13, 2013 (JP) 2013-050238

(51) **Int. Cl.**

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G02B 7/34	(2006.01)
H04N 9/04	(2006.01)
G02B 7/28	(2006.01)

(Continued)

(52) **U.S. Cl.**

CPC ***H04N 5/23212*** (2013.01); ***G02B 7/28*** (2013.01); ***G02B 7/34*** (2013.01); ***G06T 3/4007*** (2013.01); ***H04N 9/045*** (2013.01); *G03B 13/36* (2013.01); *G03B 17/14* (2013.01)

(58) **Field of Classification Search**

None

See application file for complete search history.

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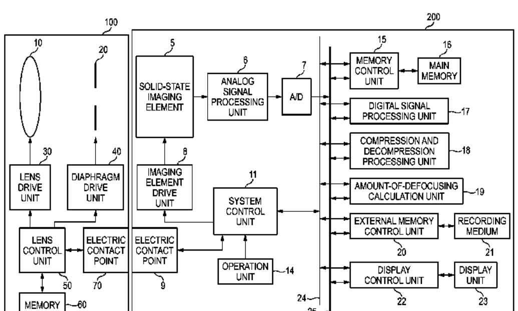
Primary Examiner — Michael Osinski

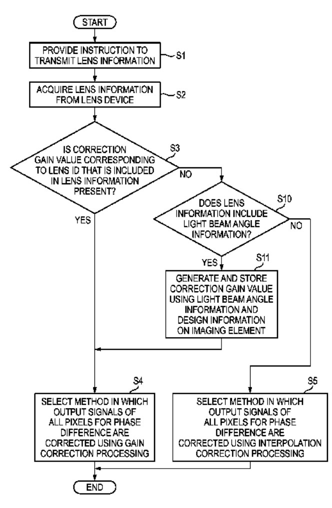
(74) *Attorney, Agent, or Firm* — Birch, Stewart, Kolasch & Birch, LLP

(57) **ABSTRACT**

There is provided a lens-exchangeable imaging device that is capable of correcting an output signal of a pixel for phase difference detection at high speed and with high precision. A camera main body **200** includes a correction method selection unit **174** that selects any of a method in which the output signals of all the pixels for phase difference detection that are included in a solid-state imaging element **5** are interpolation-corrected by an interpolation correction processing unit **172** and a method in which the output signals of all the phase difference detection are gain-corrected by a gain correction processing unit **171**, according to lens information that is acquired from a lens device **100**, and an image processing unit **175** that corrects the output signal of the pixel for phase difference detection, using the selected method.

7 Claims, 13 Drawing Sheets





(51) **Int. Cl.**

G06T 3/40	(2006.01)
G03B 13/36	(2006.01)
G03B 17/14	(2006.01)

(56) **References Cited**

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FIG. 1

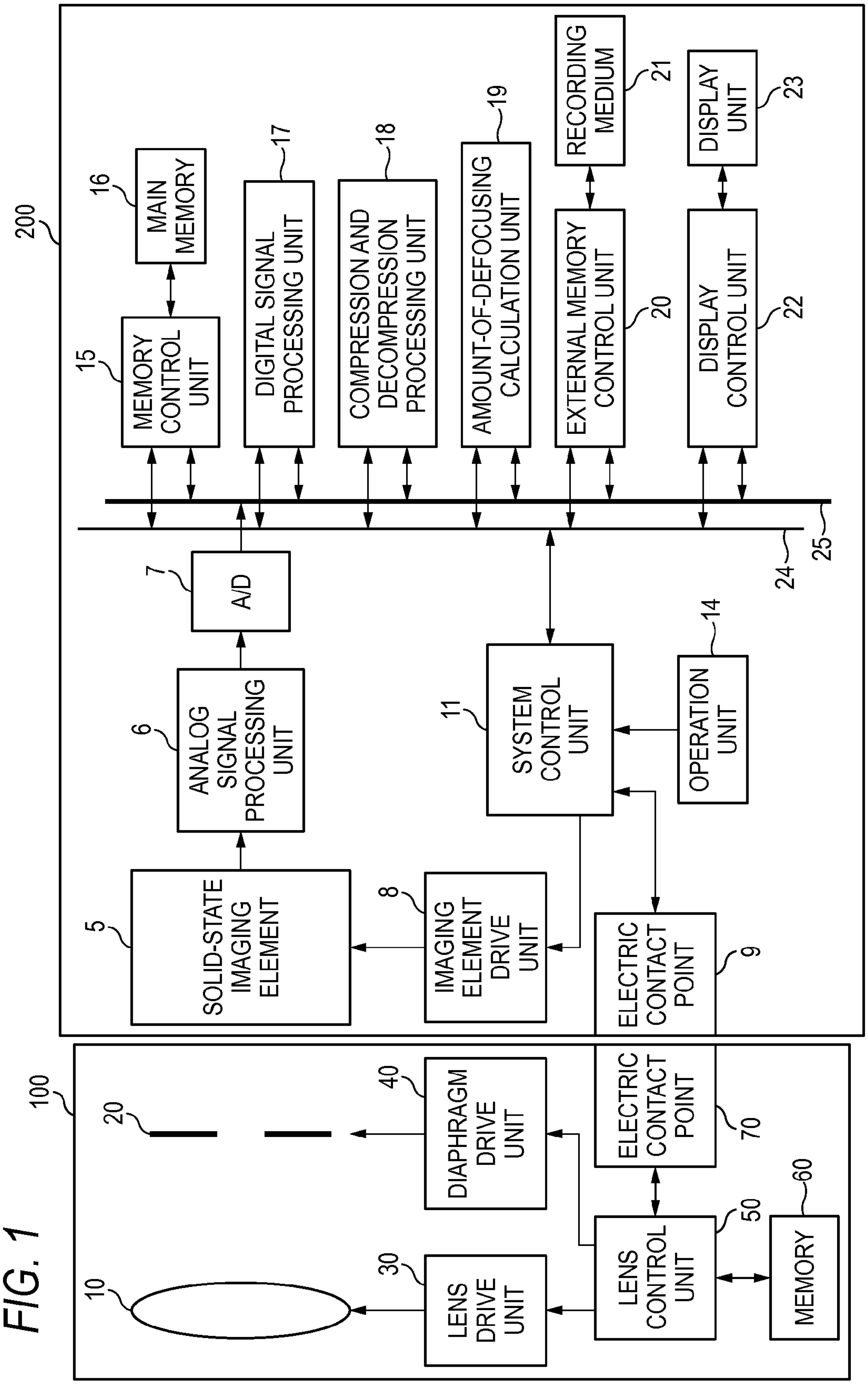

200
MEMORY CONTROL UNIT
15
MAIN MEMORY
16
DIGITAL SIGNAL PROCESSING UNIT
17
COMPRESSION AND DECOMPRESSION PROCESSING UNIT
18
AMOUNT-OF-DEFOCUSING CALCULATION UNIT
19
EXTERNAL MEMORY CONTROL UNIT
20
RECORDING MEDIUM
21
DISPLAY CONTROL UNIT
22
DISPLAY UNIT
23
24
25
A/D
7
ANALOG SIGNAL PROCESSING UNIT
6
SYSTEM CONTROL UNIT
11
OPERATION UNIT
14
SOLID-STATE IMAGING ELEMENT
5
IMAGING ELEMENT DRIVE UNIT
8
ELECTRIC CONTACT POINT
9
100
20
DIAPHRAGM DRIVE UNIT
40
ELECTRIC CONTACT POINT
70
10
LENS DRIVE UNIT
30
LENS CONTROL UNIT
50
MEMORY
60

FIG. 2

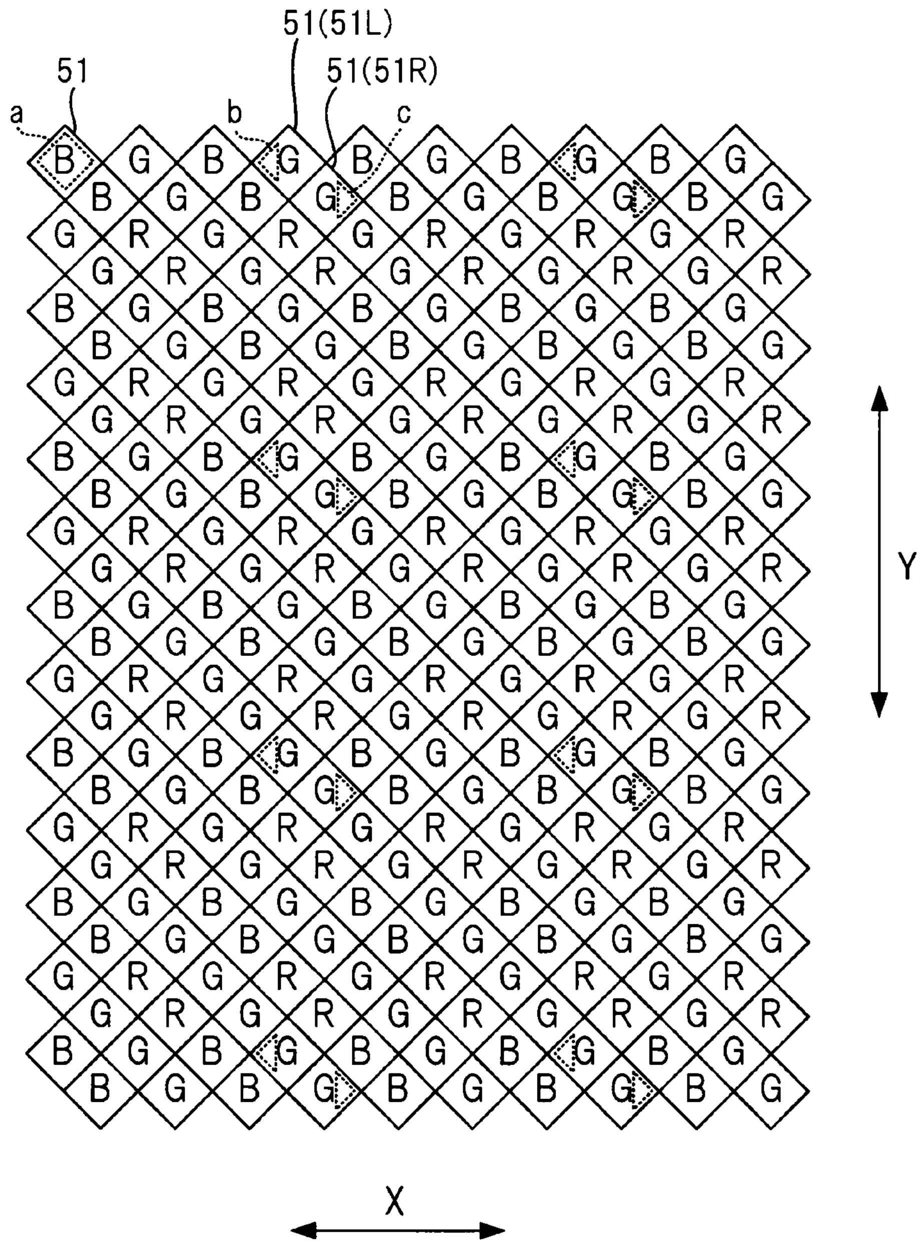


FIG. 3

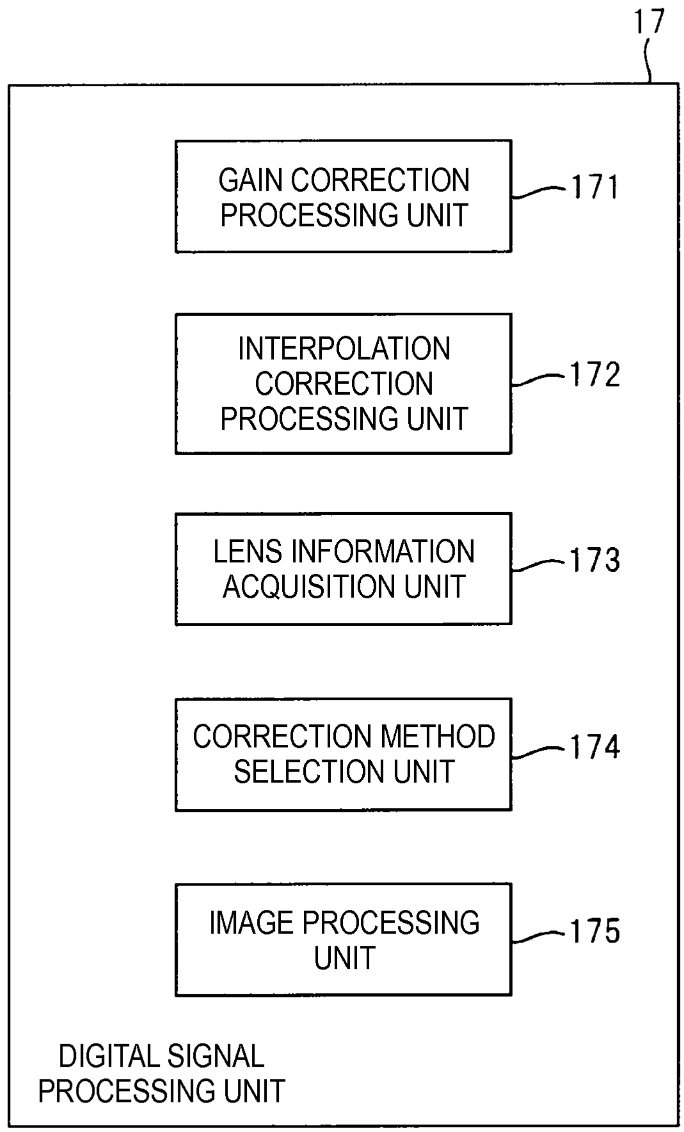

17
GAIN CORRECTION PROCESSING UNIT
171
INTERPOLATION CORRECTION PROCESSING UNIT
172
LENS INFORMATION ACQUISITION UNIT
173
CORRECTION METHOD SELECTION UNIT
174
IMAGE PROCESSING UNIT
175
DIGITAL SIGNAL PROCESSING UNIT

FIG. 4

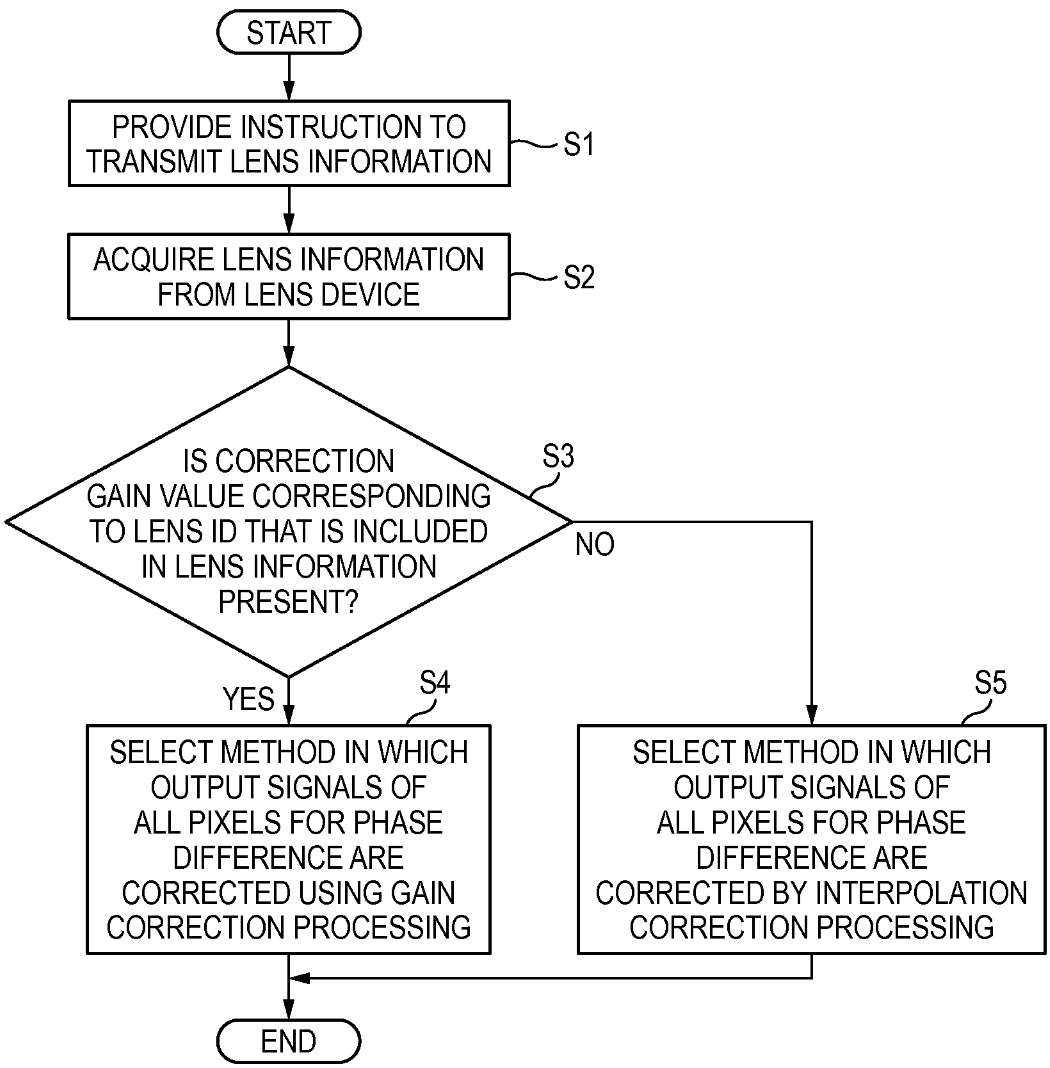

START
PROVIDE INSTRUCTION TO TRANSMIT LENS INFORMATION
S1
ACQUIRE LENS INFORMATION FROM LENS DEVICE
S2
IS CORRECTION GAIN VALUE CORRESPONDING TO LENS ID THAT IS INCLUDED IN LENS INFORMATION PRESENT?
S3
NO
YES
S4
SELECT METHOD IN WHICH OUTPUT SIGNALS OF ALL PIXELS FOR PHASE DIFFERENCE ARE CORRECTED USING GAIN CORRECTION PROCESSING
S5
SELECT METHOD IN WHICH OUTPUT SIGNALS OF ALL PIXELS FOR PHASE DIFFERENCE ARE CORRECTED BY INTERPOLATION CORRECTION PROCESSING
END

FIG. 5

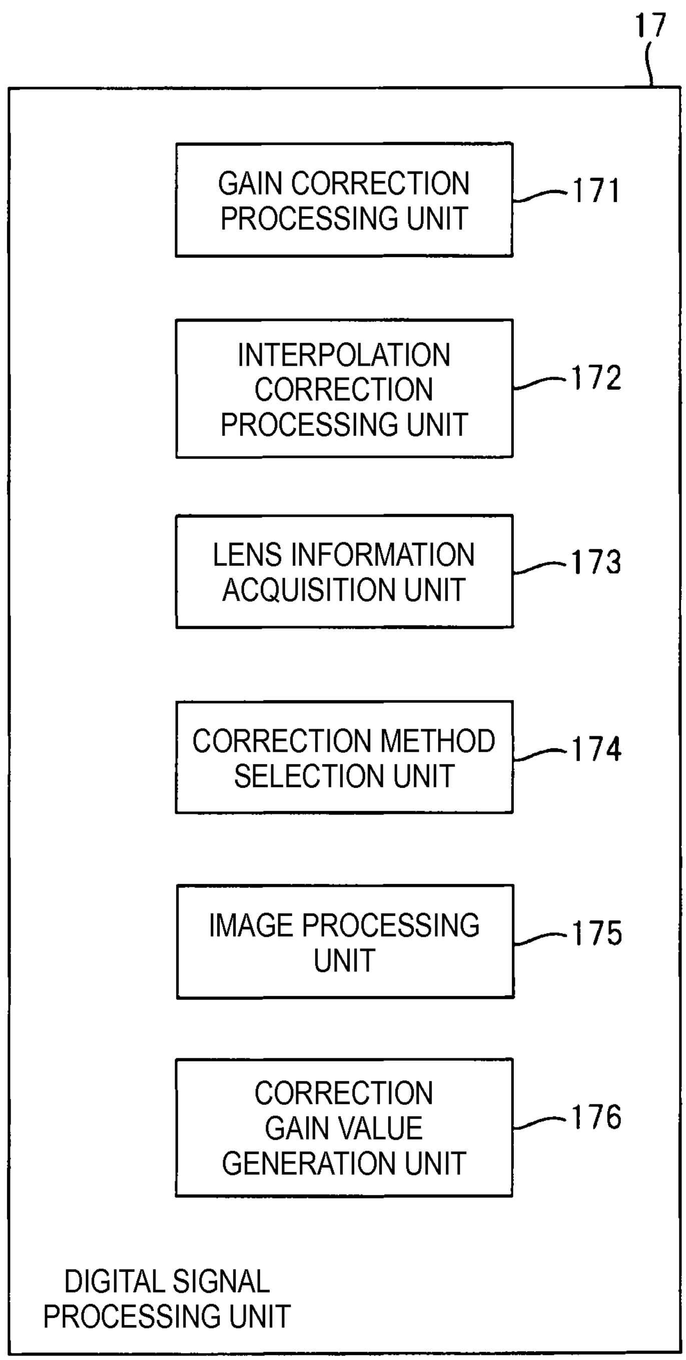
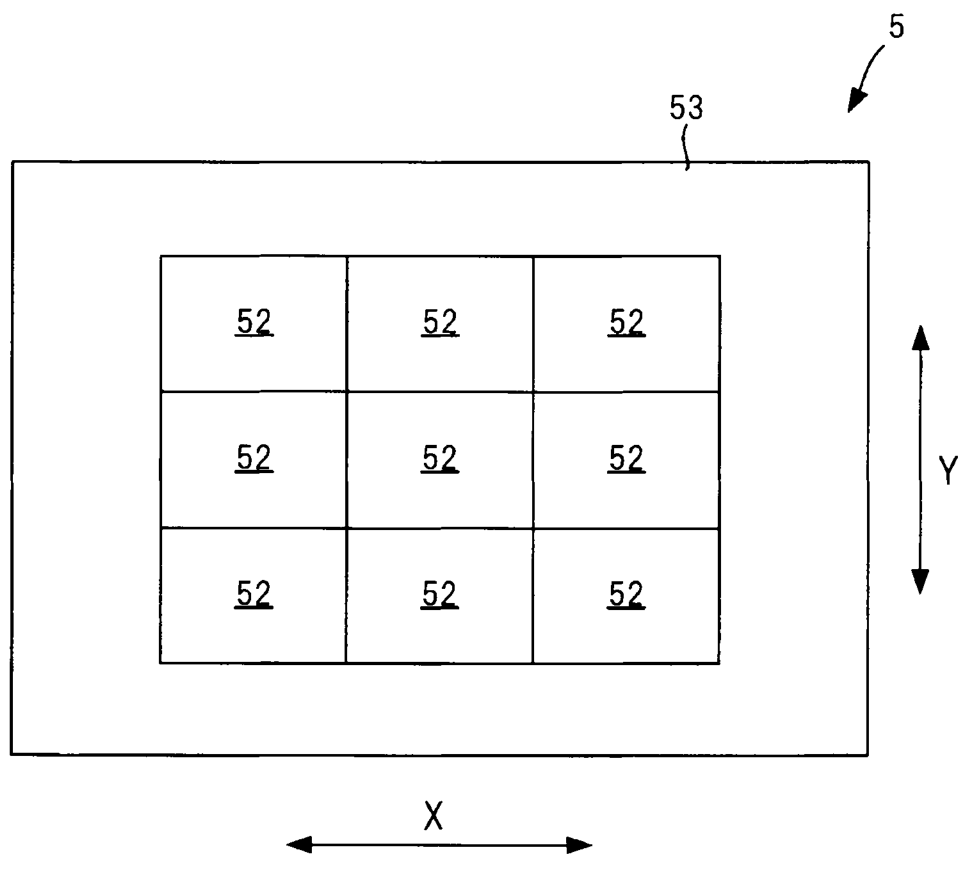

17
GAIN CORRECTION PROCESSING UNIT
171
INTERPOLATION CORRECTION PROCESSING UNIT
172
LENS INFORMATION ACQUISITION UNIT
173
CORRECTION METHOD SELECTION UNIT
174
IMAGE PROCESSING UNIT
175
CORRECTION GAIN VALUE GENERATION UNIT
176
DIGITAL SIGNAL PROCESSING UNIT

FIG. 6



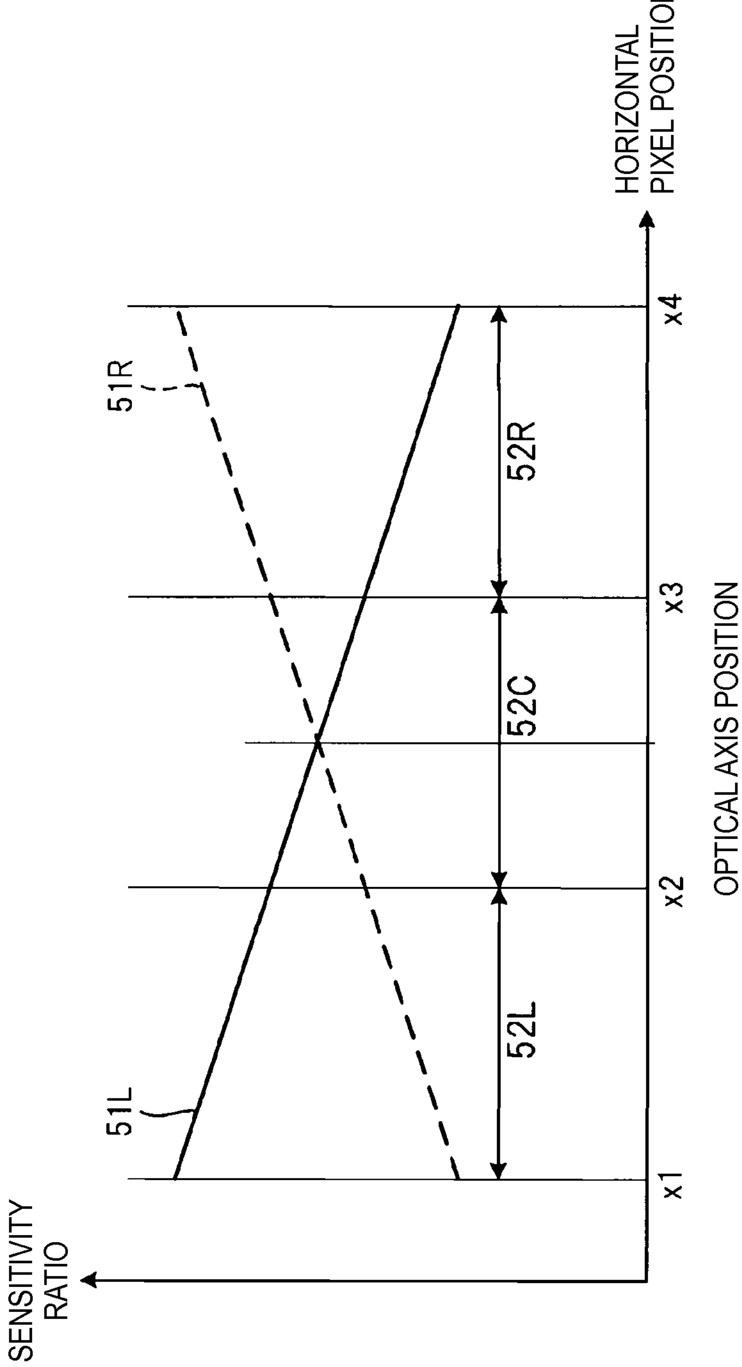

HORIZONTAL PIXEL POSITION
SENSITIVITY RATIO
OPTICAL AXIS POSITION
51R
51L
52R
52C
52L
x1
x2
x3
x4

FIG. 7

FIG. 8

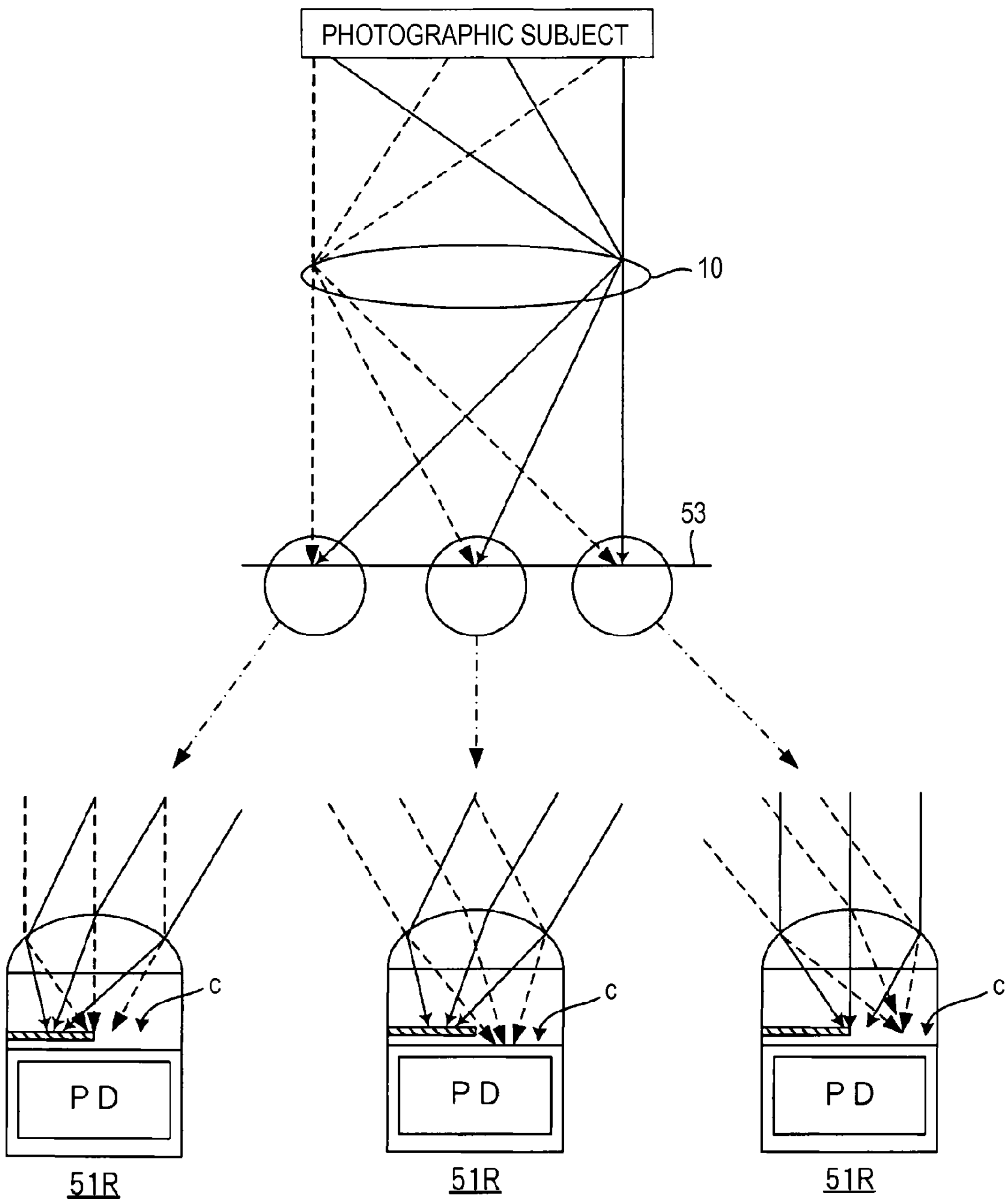
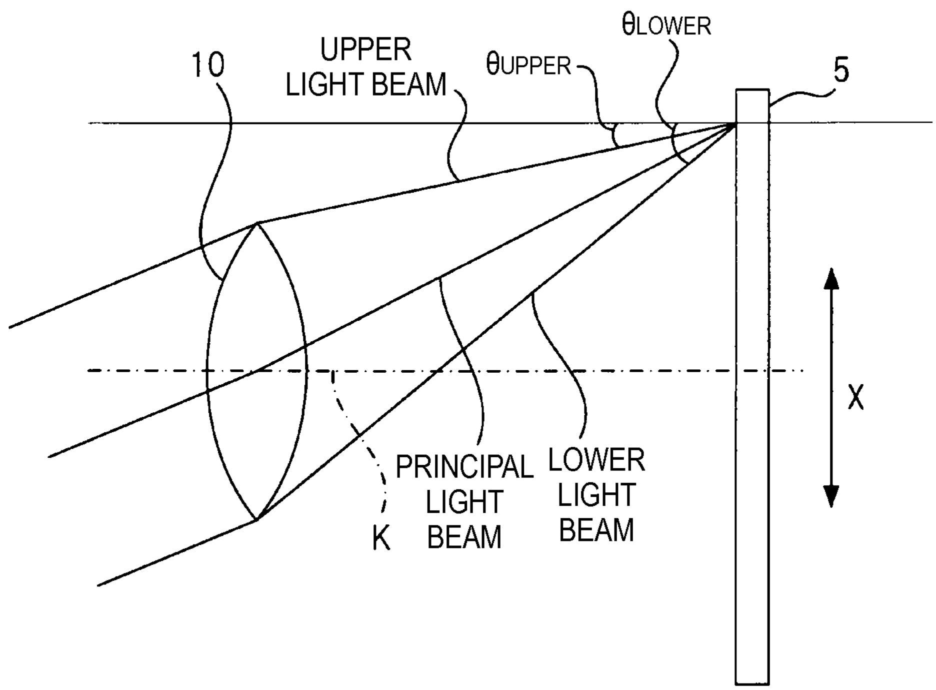


FIG. 9



10
UPPER LIGHT BEAM
θUPPER
θLOWER
5
X
K
PRINCIPAL LIGHT BEAM
LOWER LIGHT BEAM

FIG. 10

·
·
·

OPTICAL CONDITION 3	HORIZONTAL PIXEL POSITION

OPTICAL CONDITION 2	HORIZONTAL PIXEL POSITION

OPTICAL CONDITION 1	HORIZONTAL PIXEL POSITION			
	x 1	x 2	x 3	x 4
UPPER LIGHT BEAM ANGLE	θ 1a	θ 2a	θ 3a	θ 4a
LOWER LIGHT BEAM ANGLE	θ 1b	θ 2b	θ 3b	θ 4b

FIG. 11

		UPPER LIGHT BEAM ANGLE				
		θ 1a	θ 2a	θ 3a	θ 4a	· · ·
LOWER LIGHT BEAM ANGLE	θ 1b	L1,R1	L3,R3			
	θ 2b	L2,R2				
	θ 3b					
	θ 4b					
	· ·					

FIG. 12

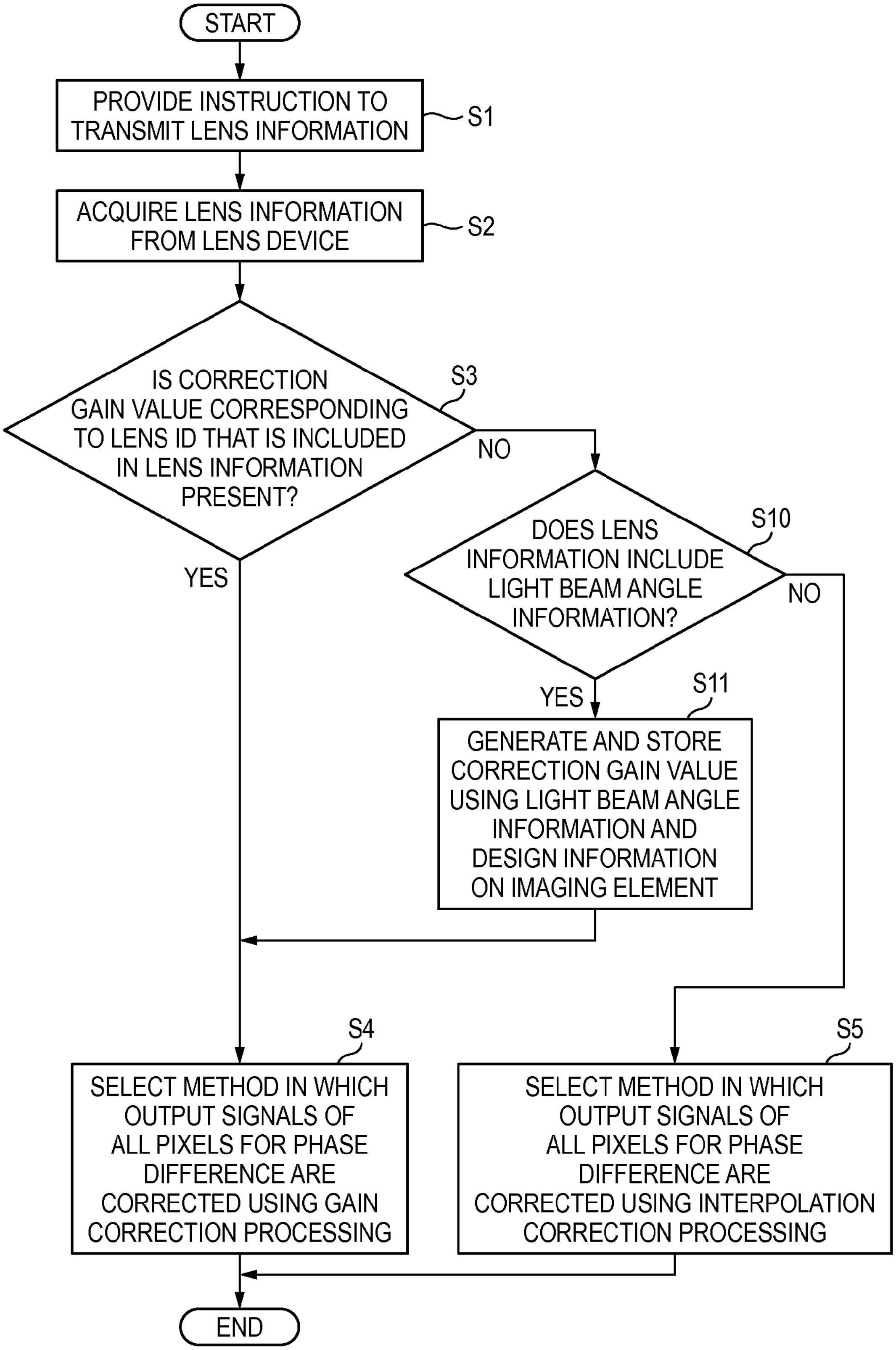
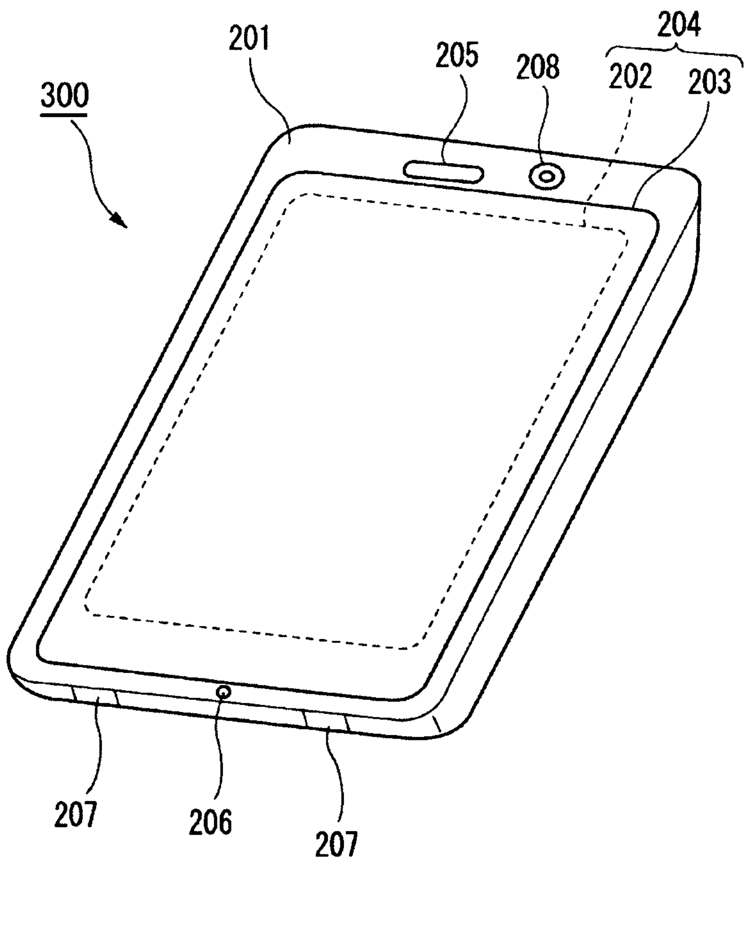
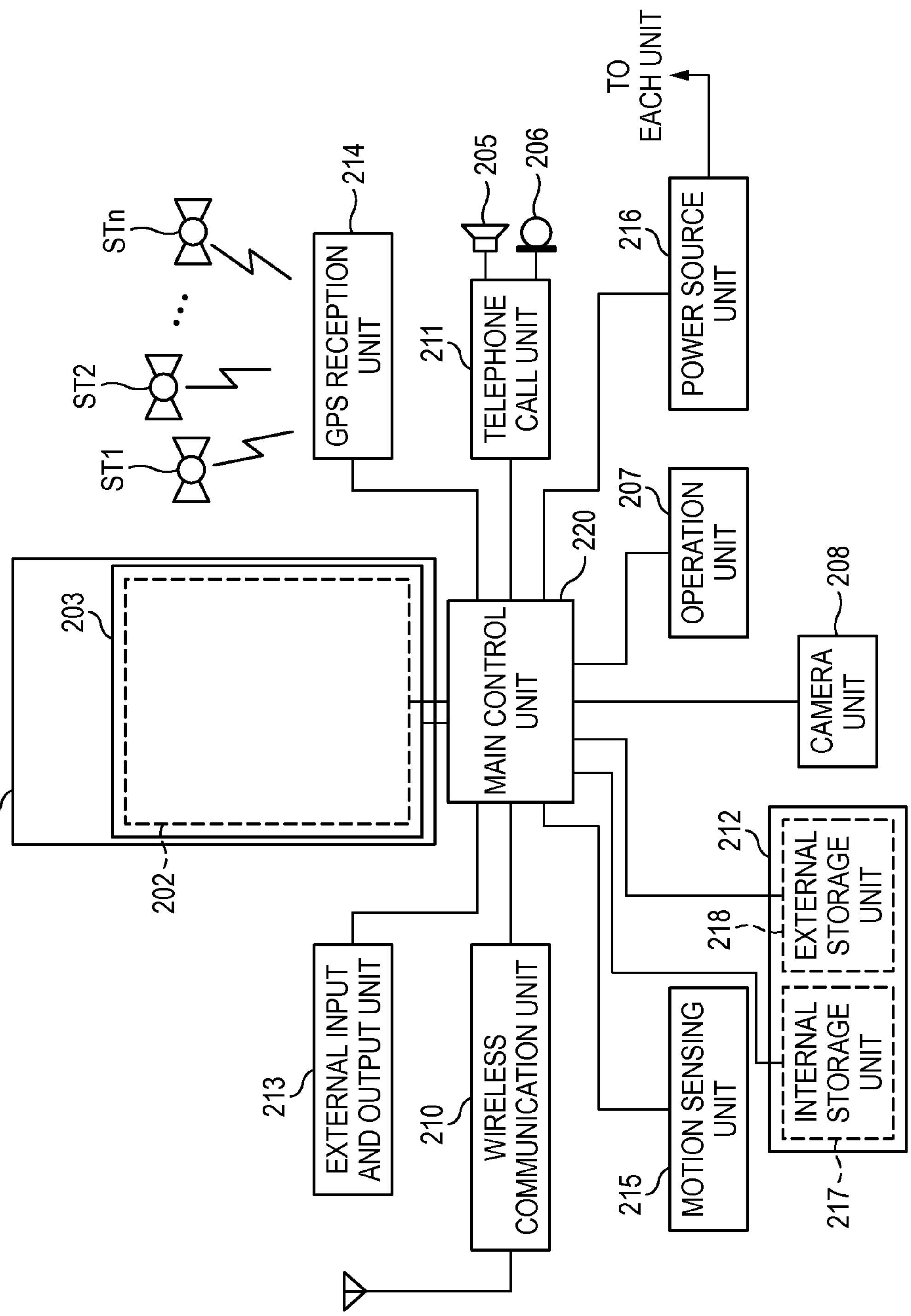

START
PROVIDE INSTRUCTION TO TRANSMIT LENS INFORMATION
S1
ACQUIRE LENS INFORMATION FROM LENS DEVICE
S2
IS CORRECTION GAIN VALUE CORRESPONDING TO LENS ID THAT IS INCLUDED IN LENS INFORMATION PRESENT?
S3
NO
YES
DOES LENS INFORMATION INCLUDE LIGHT BEAM ANGLE INFORMATION?
S10
NO
YES
S11
GENERATE AND STORE CORRECTION GAIN VALUE USING LIGHT BEAM ANGLE INFORMATION AND DESIGN INFORMATION ON IMAGING ELEMENT
S4
SELECT METHOD IN WHICH OUTPUT SIGNALS OF ALL PIXELS FOR PHASE DIFFERENCE ARE CORRECTED USING GAIN CORRECTION PROCESSING
S5
SELECT METHOD IN WHICH OUTPUT SIGNALS OF ALL PIXELS FOR PHASE DIFFERENCE ARE CORRECTED USING INTERPOLATION CORRECTION PROCESSING
END

FIG. 13





STn
ST2
ST1
GPS RECEPTION UNIT
214
TELEPHONE CALL UNIT
211
205
206
TO EACH UNIT
POWER SOURCE UNIT
216
OPERATION UNIT
207
CAMERA UNIT
208
MAIN CONTROL UNIT
220
203
204
202
EXTERNAL STORAGE UNIT
INTERNAL STORAGE UNIT
212
218
217
EXTERNAL INPUT AND OUTPUT UNIT
213
WIRELESS COMMUNICATION UNIT
210
MOTION SENSING UNIT
215

FIG. 14

IMAGING DEVICE, SIGNAL PROCESSING METHOD, AND SIGNAL PROCESSING PROGRAM

CROSS REFERENCE TO RELATED APPLICATION

This is a continuation of International Application No. PCT/JP2013/084314 filed on Dec. 20, 2013, and claims priority from Japanese Patent Application No. 2013-050238, filed on Mar. 13, 2013, the entire disclosures of which are incorporated herein by reference.

TECHNICAL FIELD

The present invention relates to an imaging device, a signal processing method, and a signal processing program.

BACKGROUND ART

In recent years, as solid-state imaging elements, such as a charge coupled device (CCD) image sensor and a complementary metal oxide semiconductor (CMOS) image sensor have had high resolution, there is a rapidly-increasing demand for information devices having a photographing function, such as a digital still camera, a digital video camera, a portable telephone, and a personal digital assistant (PDA). Moreover, the information device having an imaging function as described above is referred to as an imaging device.

As a focusing control method of focusing on a main photographic subject, there are a contrast AF (an auto focus (AF)) type and a phase difference AF type. The phase difference AF type can detect a focusing position at high speed with high precision compared with the contrast AF type, and, for this reason, is mostly employed in various imaging devices.

As a solid-state imaging element that is mounted in an imaging device which performs focusing control using the phase difference AF type, for example, a solid-state imaging element is used in which a pair of pixels for phase difference detection, on which openings in a light shielding film are decentered in the opposite directions, is discretely provided on an entire light receiving surface (refer to Patent Literatures 1 to 4).

Because an area of the opening in the light shielding film in the pixel for phase difference detection is smaller than in a different normal pixel (a pixel for imaging), the use of an output signal of the pixel for phase difference detection as an imaging-obtained image signal is insufficient. Then, there occurs a need to correct the output signal of the pixel for phase difference detection.

Patent Literatures 1 to 4 disclose an imaging device in which an interpolation correction processing that interpolation-generates the output signal for the pixel for phase difference detection using an output signal of a normal pixel in the vicinity of the pixel for phase difference detection and a gain correction processing that corrects the output signal for the pixel for phase difference detection by gain-amplifying the output signal are used together.

Patent Literature 5 discloses that processing which interpolation-generates the output signal for the pixel for phase difference detection using an output signal of a normal pixel in the vicinity of the pixel for phase difference detection is performed in the lens-exchangeable camera.

Patent Literature 6 discloses a camera in which a threshold for determining whether or not a pixel in a solid-state imaging element is a defective pixel is caused to differ using lens information that is acquired from a lens device.

CITATION LIST

Patent Literature

Patent Literature 1: JP-A-2009-44636
Patent Literature 2: JP-A-2011-124704
Patent Literature 3: JP-A-2011-81271
Patent Literature 4: JP-A-2007-282108
Patent Literature 5: JP-A-2010-91848
Patent Literature 6: JP-A-2007-19959

SUMMARY OF INVENTION

Technical Problem

In a lens-exchangeable camera that is disclosed in Patent Literatures 5 and 6, the output of the pixel for phase difference detection differs by combining an imaging element that is built into the camera and a lens that is mounted on the camera. For example, a light beam angle to an imaging element differs due to a lens, and the amount of light that enters the pixel for phase difference detection with respect to the light beam angle changes complicatedly due to a shape of the light shielding film on the imaging element, a positional relation of a photoelectric conversion area within a silicon substrate, or the like.

For this reason, in a case where the output signal of the pixel for phase difference detection in the lens-exchangeable camera is gain-corrected, there is a need for all lenses mountable on the camera to retain a gain value in advance. However, the storing of a correction gain value corresponding to all lenses in a camera brings about an increase in the cost of manufacturing a camera. Furthermore, new exchangeable lenses are always available on the market, but because there is no correction gain value for these new exchangeable lenses, gain correction cannot be performed.

In Patent Literatures 1 to 6, it is not considered how the output signal of the pixel for phase difference detection is corrected in a case where an exchangeable lens, for which the correction gain value is not stored, is mounted on the lens-exchangeable camera.

Solution to Problem

An object of the present invention, which is made in view of the situation described above, is to provide a lens-exchangeable imaging device that is capable of correcting an output signal of a pixel for phase difference detection at high speed with high precision even in a case where any lens is mounted.

Solution to Problem

An imaging device of the present invention is an imaging device to which a lens device is capable of being detachably mounted, comprising: an imaging element that includes multiple pixels for imaging arranged into a two-dimensional array and multiple pixels for phase difference detection on a light receiving surface and that images a photographic subject through the lens device; a communication unit for performing communication with the mounted lens device; a lens information acquisition unit that acquires lens information that is information specific to the lens device, from the lens device through the communication unit; a gain correction processing unit that performs gain correction processing which corrects an output signal of the pixel for phase difference detection in an imaging-obtained image signal that is obtained by the imaging element imaging the photographic subject, by multiplying the output signal by a gain value; an interpolation correction processing unit that performs interpolation correction processing which corrects the output signal of the pixel for phase difference detection in the imaging-obtained image signal by replacing the output signal with a signal that is generated using an output signal of the pixel for imaging that is in the vicinity of the pixel for phase difference detection and that detects the same color as the pixel for phase difference detection; a correction method selection unit that selects according to the lens information that is acquired by the lens information acquisition unit, any of a first correction method in which the output signals of all the pixels for phase difference detection in the imaging-obtained image signal are corrected by the interpolation correction processing unit, a second correction method in which the output signals of all the pixels for phase difference detection in the imaging-obtained image signal are corrected by the gain correction processing unit, and a third correction method in which the output signal of each pixel for phase difference detection in the imaging-obtained image signal is corrected by any of the interpolation correction processing unit and the gain correction processing unit; and an image processing unit that corrects the output signal of the pixel for phase difference detection in the imaging-obtained image signal, using the method that is selected by the correction method selection unit.

A signal processing method of the present invention is a signal processing method for use in an imaging device to which a lens device is capable of being detachably mounted, the imaging device including an imaging element that includes multiple pixels for imaging arranged into a two-dimensional array and multiple pixels for phase difference detection on a light receiving surface and that images a photographic subject through the lens device, and a communication unit for performing communication with the mounted lens device, the signal processing method comprising: a lens information acquisition step of acquiring lens information that is information specific to the lens device, from the lens device through the communication unit; a correction method selection step of selecting according to the lens information that is acquired by the lens information acquisition step, any of a first correction method in which the output signals of all the pixels for phase difference detection in the imaging-obtained image signal are corrected by interpolation correction processing that replaces the output signals with signals that are generated using an output signal of the pixel for imaging that is in the vicinity of the pixel for phase difference detection and that detects the same color as the pixel for phase difference detection, a second correction method in which the output signals of all the pixels for phase difference detection in the imaging-obtained image signal are corrected by the gain correction processing that corrects the output signals by multiplying the output signals by a gain value, and a third correction method in which the output signal of each pixel for phase difference detection in the imaging-obtained image signal is corrected by any of the interpolation correction processing and the gain correction processing; and an image processing step of correcting the output signal of the pixel for phase difference detection in the imaging-obtained image signal, using the method that is selected in the correction method selection step.

A signal processing program of the present invention is a program for causing a computer to perform each step of the signal processing method.

Advantageous Effects of Invention

According to the present invention, even in a case where any lens is mounted, a lens-exchangeable imaging device can be provided that is capable of correcting an output signal of a pixel for phase difference detection at high speed and with high precision.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** is a diagram illustrating a schematic configuration of a digital camera as one example of an imaging device for describing one embodiment of the present invention.

FIG. **2** is a diagram illustrating a planar configuration of a solid-state imaging element **5** that is mounted in the digital camera which is illustrated in FIG. **1**, which results from enlarging a part of the solid-state imaging element **5**.

FIG. **3** is a functional block diagram of a digital signal processing unit **17** in the digital camera that is illustrated in FIG. **1**.

FIG. **4** is a flowchart for describing operation of the digital camera that is illustrated in FIG. **1**.

FIG. **5** is a diagram illustrating a modification example of a functional block diagram of the digital signal processing unit **17** in the digital camera that is illustrated in FIG. **1**.

FIG. **6** is a schematic plane diagram of a configuration of the entire solid-state imaging element **5** that is mounted in the digital camera which is illustrated in FIG. **1**.

FIG. **7** is a diagram illustrating sensitivity ratios for pixels **51**R and **51**L for phase difference detection at a position (a horizontal pixel position) in the row direction X in the solid-state imaging element **5**.

FIG. **8** is a diagram for describing how the sensitivity ratio in FIG. **7** is attained.

FIG. **9** is a diagram for describing an incident light beam angle in an arbitrary position in the row direction X, of the solid-state imaging element **5**.

FIG. **10** is a diagram illustrating one example of data that is stored in a memory **60** of a lens device **100**.

FIG. **11** is a diagram illustrating one example of a table that is stored in a main memory **16** of a camera main body **200**.

FIG. **12** is a flowchart for describing operation of a digital signal processing unit **17** that is illustrated in FIG. **5**.

FIG. **13** is a diagram for describing a smartphone as an imaging device.

FIG. **14** is a block diagram of the inside of the smartphone in FIG. **13**.

DESCRIPTION OF EMBODIMENTS

Embodiments of the present invention will be described below referring to the drawings.

FIG. **1** is a diagram illustrating a schematic configuration of a digital camera as one example of an imaging device for describing one embodiment of the present invention.

The digital camera that is illustrated in FIG. **1** includes a lens device **100** as an imaging optical system and a camera main body **200** including a mount mechanism not illustrated, in which the lens device **100** is to be mounted. The lens device **100** is detachably attachable to the camera main body **200** and is replaceable with others.

The lens device **100** includes a photographing lens **10** that includes a focal lens, a zoom lens, and the like, a diaphragm **20**, a lens drive unit **30**, a diaphragm drive unit **40**, a lens control unit **50** that integrally controls the entire lens device **100**, a memory **60**, and an electric contact point **70**. The focal lens here is a lens that moves in an optical axis direction, and thus adjusts a focal point distance in a photographing optical system. The focal lens indicates a lens that adjusts a focal point position in a lens unit that is configured from multiple lenses and, in the case of lenses for all-group extension, indicates all groups as a whole.

According to an instruction from the lens control unit **50**, the lens drive unit **30** is set to adjust position of the focal lens that is included in the photographing lens **10** and to perform adjustment of a position of the zoom lens that is included in the photographing lens **1**.

According to the instruction from the lens control unit **50**, the diaphragm drive unit **40** controls the amount of opening on the diaphragm **20**, and thus performs adjustment of an amount of light exposure.

Lens information that is information specific to the lens device **100** is stored in the memory **60**. The lens information includes at least a lens ID as identification information for identifying the lens device **100**.

The electric contact point **70** is an interface for performing communication between the lens device **100** and the camera main body **200**. The electric contact point **70** comes into contact with an electric contact point **9** that is provided on the camera main body **200**, in a state where the lens device **100** is mounted on the camera main body **200**. The electric contact point **9** functions as a communication unit for performing communication with the lens device **100**.

The camera main body **200** includes a solid-state imaging element **5**, such as a CCD type, a CMOS type, and the like, which images a photographic subject through the lens device **100**, an analog signal processing unit **6** that is connected to an output of the solid-state imaging element **5** and that performs analog signal processing, such as correlative double sampling processing, and an A/D conversion circuit **7** that converts an analog signal that is output from the analog signal processing unit **6**, into a digital signal. The analog signal processing unit **6** and the A/D conversion circuit **7** are controlled by a system control unit **11**. The analog signal processing unit **6** and the A/D conversion circuit **7** are also built into the solid-state imaging element **5**.

The system control unit **11** drives the solid-state imaging element **5** through an imaging element drive unit **8**, and outputs an image of the photographic subject that is imaged by the photographing lens **10**, as an imaging-obtained image signal. An instruction signal from a user is input into the system control unit **11** through an operation unit **14**.

An electric control system of the digital camera further includes a main memory **16**, a memory control unit **15** that is connected to the main memory **16**, a digital signal processing unit **17** that performs interpolation calculation, gamma correction calculation, RGB/YC conversion processing, and the like on the imaging-obtained image signal that is output from the A/D conversion circuit **7** and a compression and decompression processing unit **18** that compresses the imaging-obtained image data which is generated in the digital signal processing unit **17**, in a JPEG format, and decompresses the compressed image data, an amount-of-defocusing computation unit **19** that calculates the amount of defocusing, an external memory control unit **20** to which a recording medium **21** that is freely detachably attachable is connected, and a display control unit **22** to which a display unit **23** that is mounted on a rear surface of a camera. The memory control unit **15**, the digital signal processing unit **17**, the compression and decompression processing unit **18**, the amount-of-defocusing computation unit **19**, the external memory control unit **20**, and the display control unit **22** are connected to each other through a control bus **24** and a data bus **25**, and are controlled according to an instruction from the system control unit **11**.

FIG. **2** is a diagram illustrating a planar configuration of the solid-state imaging element **5** that is mounted in the digital camera which is illustrated in FIG. **1**, which results from enlarging a part of the solid-state imaging element **5**.

The solid-state imaging element **5** includes multiple pixels **51** (square blocks in the drawing) that are arranged two-dimensionally in the row direction X and the column direction Y that intersects the row direction X. All the pixels **51** are not illustrated in FIG. **2**, and in practice, approximately several millions to ten millions of pixels **51** are two-dimensionally arranged. When the solid-state imaging element **5** performs imaging, an output signal is obtained from each of the multiple pixels **51**. A set of multiple output signals that are obtained is referred to as an imaging-obtained image signal in the present specification.

Each pixel **51** includes a photoelectric conversion component such as a photo diode, and a color filter that is formed on the photoelectric component.

In FIG. **2**, a letter "R" is assigned to a pixel **51** that includes a color filter that allows a red light to pass through, a letter "G" is assigned to a pixel **51** that includes a color filter that allows a green light to pass through, and a letter "B" is assigned to a pixel **51** that includes a color filter that allows a blue light to pass through.

Multiple pixels **51** are such that multiple rows of multiple pixels **51** that are arranged side by side in the row direction X are arranged side by side in the column direction Y. Then, odd-numbered pixel row and even-numbered pixel row are shifted by approximately half of an array pitch of pixels **51** in each pixel row in the row direction X.

An array of color filters that are included in pixels **51** in the odd-numbered pixel row is a Bayer array as a whole. Furthermore, an array of color filters that are included in pixels **51** in the even-numbered pixel row is a Bayer array as a whole as well. A pixel **51** in the odd-numbered row, and a pixel **51** that is vertically adjacent to the pixel **51** in the odd-numbered row and that detects the same color light as the pixel **51** in the odd-numbered row constitute a pair pixel.

With the solid-state imaging element **5** in this pixel array, output signals of two pixels **51** that constitute the pair pixel are added up and thus high-sensitivity of a camera can be achieved. Furthermore, exposure times of the two pixels **51** that constitute the pair pixel are changed and the output signals of the two pixels **51** are added up, and thus a broad dynamic range in the camera can be achieved.

In the solid-state imaging element **5**, some of multiple pixels **51** are pixels for phase difference detection.

The pixels for phase difference detection include multiple pixels **51**R for phase difference detection and multiple pixels **51**L for phase difference detection.

The multiple pixels **51**R for phase difference detection output signals according to an amount by which one pencil (for example, a pencil of light that passes through the right half of a pupil area) in a pair of pencils of light that pass through different parts of a pupil area of the photographing lens **1** is received. To be more precise, the multiple pixels **51**R for phase difference detection, which are provided in the solid-state imaging element **5**, captures an image that is formed by one pencil in the pair of pencils of light.

The multiple pixels **51**L for phase difference detection output signals according to the amount by which the other pencil (for example, a pencil of light that passes through the left half of the pupil area) in the pair of pencils of light is received. To be more precise, the multiple pixels **51**L for phase difference detection, which are provided in the solid-state imaging element **5**, captures an image that is formed by the other pencil in the pair of pencils of light.

Moreover, multiple pixels **51** (hereinafter referred to as pixels for imaging) other than the pixels **51**R and **51**L for phase difference detection capture images that are formed by pencils of light that pass through almost all parts of the pupil area of the photographing lens **1**.

A light shielding film is provided above the photoelectric conversion component of the pixel **51**, and an opening that stipulates a light receiving area of the photoelectric conversion component is formed in the light shielding film.

The center of the opening (which is indicated by a letter a in FIG. **2**) of a pixel **51** for imaging agrees with the center (the center of a square block) of the photoelectric conversion component of the pixel **51** for imaging. Moreover, in FIG. **2**, the opening a in only one pixel **51** for imaging is illustrated for figure simplification.

In contrast, the center of an opening (which is indicated by a letter c in FIG. **2**) in the pixel **51**R for phase difference detection is decentered to the right side with respect to the center of the photoelectric conversion component of the pixel **51**R for phase difference detection.

The center of an opening (which is indicated by a letter b in FIG. **2**) in the pixel **51**L for phase difference detection is decentered to the left side with respect to the center of the photoelectric conversion component of the pixel **51**L for phase difference detection.

In the solid-state imaging element **5**, one part of the pixel **51** on which a color filter for green is mounted is the pixel **51**R for phase difference detection or the pixel **51**L for phase difference detection. Of course, a pixel on which a color filter for different color is mounted may be set to be the pixel for phase difference detection.

Pairs (hereinafter referred to a phase difference pair) of the pixel **51**R for phase difference detection and the pixel **51**L for phase difference detection that is arranged adjacent to the pixel **51**R for phase difference detection are arranged in a discrete and periodic manner in a light receiving surface **53** in which the pixels **51** are arranged.

In the present specification, two pixels that are adjacent to each other refers to two pixels that are adjacent to each other to the extent to which lights from parts of substantially the same photographic subject can be regarded as being received. Moreover, because the pixel **51**R for phase difference detection and the pixel **51**L for phase difference detection that constitute the phase difference pair are adjacent to each other, the pixel **51**R and the pixel **51**L are handled as being identical to each other in terms of a position in the row direction X (hereinafter also referred to as a horizontal pixel position).

In an example in FIG. **2**, one pixel **51**R for phase difference detection is arranged each time three pixels in the row direction X, in one part of the even-numbered pixel row (four pixel rows that are arranged side by side each time three pixel rows are arranged, in the example in FIG. **2**).

In the example in FIG. **2**, the pixel **51**L for phase difference detection is arranged in the row direction X with the same period as the pixel **51**R for phase difference detection in one part (a row of pixels which is adjacent to a row of pixels that include the pixel **51**R for phase difference detection) of the odd-numbered pixel row.

With this configuration, a light that enters the pixel **51**L for phase difference detection through the opening b in the light shielding film is mostly a light from the left side when viewed from the photographic subject whose image is seen through the photographing lens **1** that is provided in the direction from which a sheet of paper on which FIG. **2** is drawn is viewed, that is, a light that comes from the direction in which the photographic subject is viewed with the right eye. Furthermore, a light that enters the pixel **51**R for phase difference detection through the opening c in the light shielding film is mostly a light from the right side when viewed from the photographic subject whose image is seen through the photographing lens **1**, that is, a light that comes from the direction in which the photographic subject is viewed with the left eye.

That is, with all the pixels **51**R for phase difference detection, the imaging-obtained image signal that results when the photographic subject is viewed with the left eye can be obtained, and with all the pixel **51**L for phase difference detection, the imaging-obtained image signal that results when the photographic subject is viewed with the right eye can be obtained. For this reason, with a combination of the two imaging-obtained image signals, it is possible to generate stereoscopic image data on the photographic subject, and, with correlative computing operation of the two imaging-obtained image signals, it is possible to generate phase difference information.

Moreover, the pixel **51**R for phase difference detection and the pixel **51**L for phase difference detection can be set to receive the pencils of light that pass through different parts, respectively, of the pupil area of the photographing lens **1**, by decentering the opening in the light shielding film in the reverse direction, and thus the phase difference information can be obtained. However, a structure for obtaining the phase difference information is not limited to this, a structure can be employed that is more widely known.

FIG. **3** is a functional block diagram of the digital signal processing unit **17** in the digital camera that is illustrated in FIG. **1**.

The digital signal processing unit **17** includes a gain correction processing unit **171**, an interpolation correction processing unit **172**, a lens information acquisition unit **173**, a correction method selection unit **174**, and an image processing unit **175**. These are functional blocks that are formed by a program being executed by a processor that is included in the digital signal processing unit **17**.

The gain correction processing unit **171** performs gain correction processing that corrects an output signal of a pixel for phase difference detection (hereinafter referred to as a correction target pixel), which is included in the imaging-obtained image signal, by multiplying the output signal by a gain value.

In a case where the lens device **100** that is mounted on the camera main body **200** is a genuine product that is manufactured by a maker of the camera main body **200**, the gain value can be stored in advance in a memory of the camera main body **200**. The gain value can be obtained from the imaging-obtained image signal that is obtained by capturing a reference image in an adjustment process before shipment of a digital camera. The gain value for every pixel **51** for phase difference detection in the genuine lens device **100** is stored in the main memory **16** of the camera main body **200**, in a state of being associated with a lens ID for identifying the lens device **100**. Moreover, the gain value may be generated and stored for every pixel **51** for phase difference detection. A light receiving surface of the solid-state imaging element **5** may be divided into blocks and one gain value may be generated and stored for every block.

The interpolation correction processing unit **172** performs correction by replacing an output signal of the correction target pixel with a signal that is generated using output signals of the pixels for imaging, which are in the vicinity of the correction target image and which detect the same color as that of the correction target pixel.

For example, in a case where the output signal of the correction target pixel is corrected by the interpolation correction processing, an output signal value of the correction target pixel is replaced with an average value of the output signals of the pixels for imaging, which are in the vicinity of the correction target image and which detect a G color light. The interpolation correction processing unit **172** may perform the correction by replacing the output signal of the correction target image with a copy of the output signal of any pixel for imaging that is in the vicinity of the correction target pixel.

The lens information acquisition unit **173** acquires the lens information that is stored in the memory **60** of the lens device **100**, from the lens device **100** that is mounted on the camera main body **200**.

According to the lens information that is acquired by the lens information acquisition unit **173**, the correction method selection unit **174** selects any one of a first correction method in which, in the imaging-obtained image signal that is output from the solid-state imaging element **5**, the output signals of all the pixels for phase difference detection are corrected by the interpolation correction processing unit **172**, and a second correction method in which, in the imaging-obtained image signal that is output from the solid-state imaging element **5**, the output signals of all the pixels for phase difference detection are corrected by the gain correction processing unit **171**.

The image processing unit **175** corrects the output signal of the pixel for phase difference detection among the imaging-obtained image signals that are output from the solid-state imaging element **5**, using the method that is selected by the correction method selection unit **174**, and stores the post-correction imaging-obtained image signal in the main memory **16**. Then, the image processing unit **175** performs known image processing operations, such as de-mosaic processing, γ correction processing, white balance adjustment, on the recorded imaging-obtained image signal, and thus generates imaging-obtained image data, and record the imaging-obtained image data in the recording medium **21**.

Moreover, the image processing unit **175** may record the post-correction imaging-obtained image signal in the recording medium **21** as raw data without any change.

Operation of the digital camera that is configured as described above is described.

FIG. **4** is a flowchart for describing the operation of the digital camera that is illustrated in FIG. **1**.

In a state where the camera main body **200** is powered on, when the lens device **100** is mounted on the camera main body **200**, the system control unit **11** of the camera main body **200** detects through the electric contact point **9** that the lens device **100** is attached. When it is detected that the lens device **100** is mounted, the system control unit **11** requests the lens device **100** to transmit lens information through the electric contact point **9** (Step **S1**).

When requested to transmit the lens information, the lens control unit **50** of the lens device **100** transmits the lens information that is stored in the memory **60**, to the camera main body **200** through the electric contact point **70**. The system control unit **11** receives the lens information that is transmitted from the lens device **100**, and stores the received lens information temporarily in the main memory **16**.

The digital signal processing unit **17** acquires the lens information that is stored in the memory **16** (Step S**2**), and searches the memory **16** for data with a correction gain value that is associated with a lens ID that is included in the lens information (Step S**3**).

In a case where such data is present, the digital signal processing unit **17** selects the second correction method in which, in the imaging-obtained image signal that is output from the solid-state imaging element **5**, the output signals of all the pixels for phase difference detection is corrected by the gain correction processing unit **171** (Step S**4**). On the other hand, in a case where the data is not present, the digital signal processing unit **17** selects the first correction method in which, in the imaging-obtained image signal that is output from the solid-state imaging element **5**, the output signals of all the pixels for phase difference detection is corrected by the interpolation correction processing unit **172** (Step S**5**).

When the processing operations in Steps S**4** and S**5** are finished, a photographing waiting state is attained. When a photographing instruction is present that is generated by pushing down on a shutter button which is included in the operation unit **14**, photographing is performed by the solid-state imaging element **5** and the imaging-obtained image signal is output from the solid-state imaging element **5**. The analog signal processing is performed on the imaging-obtained image signal, and then the imaging-obtained image signal is converted into a digital signal and is temporarily stored in the main memory **16**.

Thereafter, the digital signal processing unit **17** corrects the output signal of the pixel **51** for phase difference detection in the imaging-obtained image signal that is stored in the main memory **16**, according to the method that is selected in Step S**4** or Step S**5**, processes a post-correction imaging-obtained image signal, generates imaging-obtained image data, stores the generated imaging-obtained image data on the recording medium **21**, and thus ends imaging processing.

In this manner, in a case where the lens device **100** in which the correction gain value that is used for the gain correction processing is stored in the memory **16** and which is a genuine product that is manufactured by the maker of the camera main body **200** is mounted, the digital camera in FIG. **1** corrects the output signals of all the pixels **51** for phase difference detection using the gain correction processing. On the other hand, in a case where the lens device **100** in which the correction gain value is not stored in the memory **16** and which is a product that is manufactured by another maker is mounted, the output signals of all the pixels **51** for phase difference detection is corrected using the interpolation correction processing. For this reason, it is possible to perform the correction of the output signal of the pixel **51** for phase difference detection on all the lens device that are mountable on the camera main body **200** without any problem.

Furthermore, when the digital camera is used, there is no need to store the correction gain value that corresponds to the lens device **100** manufactured by another maker, in advance in the memory **16** of the camera main body **200**. For this reason, the time taken to generate data can be reduced and memory capacity can be reduced. Thus, a cost of manufacturing a digital camera can be reduced.

Moreover, if the lens device **100** is a genuine product that is manufactured by the maker of the camera main body **200**, it is considered that the correction gain value that corresponds to the lens device **100** is stored in the memory **60** of the lens device **100**, not the camera main body **200**, in a state of being associated with the lens ID.

In this case, the system control unit **11** determines in Step S**3** in FIG. **4** whether or not the correction gain value that corresponds to the lens ID which is stored in the acquired lens information is included in any of the memory **16** of the camera main body **200** and the memory **60** of the lens device **100**. The system control unit **11** performs processing in Step S**4** if the correction gain value is stored, and performs processing in Step S**5** if the correction gain value is not stored.

Next, a modification example of the digital camera that is illustrated in FIG. **1** is described.

FIG. **5** is a functional block diagram illustrating a modification example of the digital signal processing unit **17** in the digital camera that is illustrated in FIG. **1**. The digital signal processing unit **17** that is illustrated in FIG. **5** is the same as the one that is illustrated in FIG. **3**, except for the fact that a correction gain value generation unit **176** is added.

In a case where information (hereinafter referred to as light beam angle information) relating to a light beam angle in the lens device **100** is included in the lens information, the correction gain value generation unit **176** generates the correction gain value for every pixel **51** for phase difference detection, using the light beam angle information and pieces of design information (pieces of information, such as a chip size, the number of pixels, a shape of an opening in the light shielding film on the pixel for phase difference direction, a shape of a photoelectric conversion area within a silicon substrate) on the solid-state imaging element **5**. The correction gain value generation unit **176** stores the generated correction gain value in the main memory **16**, in a state of being associated with the lens ID that is included in the lens information.

A method of generating the correction gain value using the light beam angle information and the design information on the solid-state imaging element **5** will be described.

FIG. **6** is a schematic plane diagram illustrating a configuration of the entire solid-state imaging element **5** that is mounted in the digital camera which is illustrated in FIG. **1**.

The solid-state imaging element **5** has the light receiving surface **53** on which the pixels **51** are arranged. Then, in an example in FIG. **6**, nine phase difference detection areas (AF areas) **52** that are phase difference detection targets are provided on the light receiving surface **53**.

The AF area **52** is an area that includes multiple phase difference pairs that are arranged side by side in the row direction X. Only the pixels **51** for imaging are arranged in an area other than the AF area **52** in the light receiving surface **53**.

Among the nine AF areas **52** that are illustrated in FIG. **6**, each of the three AF areas **52** that are right in the middle in the row direction X is an area that has the width in the row direction X across a straight line that passes an intersection point between the light receiving surface **53** and an optical axis of the imaging lens **1** and extends in the column direction Y, when viewed from above. A position in the row direction X of the intersection point between the light receiving surface **53** and the optical axis of the imaging lens **1** is referred to as an axial position.

The amount-of-defocusing computation unit **19** that is illustrated in FIG. **1** computes the amount of phase difference that is the amount of relative deviation between two images that are formed by the pair of pencils of light, using a group of output signals that are read from the pixel **51**L for phase difference detection and the pixel **51**R for phase difference detection which are in one AF area **52** that is selected by a user operation and the like from among the nine AF areas **52**. Then, based on the amount of phase difference, a focal point adjustment state of the photographing lens **1**, which, here, is the amount of and a direction of deviation from the focusing state, that is, an amount of defocusing, is obtained.

Based on the amount of defocusing that is computed by the amount-of-defocusing computation unit **19**, the system control unit **11** that is illustrated in FIG. **1** moves the focal lens that is included in the imaging lens **1** to a focusing position and thus controls a focusing state of the imaging lens **1**.

The openings in the pixel **51**R for phase difference detection and the pixel **51**L for phase difference detection are decentered in the reverse direction. For this reason, even if positions are almost the same in the direction of decentering the openings (the direction of deviation between a pair of images); the row direction X in FIG. **2**), a difference in sensitivity occurs between the pixel **51**R for phase difference detection and the pixel **51**L for phase difference detection.

FIG. **7** is a diagram illustrating sensitivity ratios for the pixels **51**R and **51**L for phase difference detection that constitute the phase difference pair that is at an arbitrary position (hereinafter referred to as a horizontal pixel position) in the row direction X in the solid-state imaging element **5**.

A straight line that is indicated by reference character **51**R in FIG. **7** indicates the sensitivity ratio for the pixel **51**R for phase difference detection, and a straight line that is indicated by reference character **51**L indicates the sensitivity ratio of the pixel **51**L for phase difference detection.

An arbitrary sensitivity ratio for the pixel for phase difference detection is referred to as a value that is expressed as A/B or B/A when an output signal of an arbitrary pixel for phase difference detection and an output signal of a pixel for imaging (only a pixel that detects the same light as the arbitrary pixel for phase difference detection) adjacent to the arbitrary pixel for phase difference detection are defined as A and B, respectively. FIG. **7** is a diagram that results when the sensitivity ratio is expressed as NB.

In FIG. **7**, a range of horizontal pixel positions of three AF areas **52** that are in the left end portion of FIG. **6** is indicated by reference character **52**L. Furthermore, a range of horizontal pixel positions of three AF areas **52** that are in the middle portion of FIG. **6** is indicated by reference character **52**C. Furthermore, a range of horizontal pixel positions of three AF areas **52** that are in the right portion of FIG. **6** is indicated by reference character **52**R.

In FIG. **7**, a horizontal pixel position of a left end portion in a range **52**L is indicated by x**1**, a horizontal pixel position of a right end portion in a range **52**L is indicated by x**2**, a horizontal pixel position of a right end portion in a range **52**C is indicated by x**3**, and a horizontal pixel position of a right end portion in a range **52**R is indicated by x**4**.

The pixels **51**R AND **51**L for phase difference detection are arranged periodically in the column direction Y as well. However, because the openings of the pixel **51**R for phase difference detection and the pixel **51**L for phase difference detection are not decentered in the column direction Y as well, a sensitivity ratio at any position in the column direction Y is as illustrated in FIG. **7**.

Because each of the output signals of the pixel **51**R for phase difference detection and the pixel **51**L for phase difference detection individually has a different level at every horizontal pixel position due to a photographic subject, what a sensitivity distribution of the pixel for phase difference detection will look like is not understood. However, as illustrated in FIG. **7**, if the sensitivity ratio, which is a ratio between the output signals of the pixel for phase difference detection and the pixel of imaging adjacent to the pixel for phase difference detection, is obtained, the sensitivity distribution of the pixel for phase difference detection can be known.

The opening c of the pixel **51**R for phase difference detection is decentered to the right side in FIG. **2**. For this reason, as illustrated in FIG. **8**, half of a light that passes through the left side of the photographing lens **10** enters the opening c of the pixel **51**R for phase difference detection that is on the left side of the light receiving surface **53**, and a light that passes through the right side of the photographing lens **10** does not enter the opening c of the pixel **51**R for phase difference detection. On the other hand, half of a light that passes through the right side of the photographing lens **10** enters the opening c of the pixel **51**R for phase difference detection that is on the right side of the light receiving surface **53**, and all lights that pass through the left side of the photographing lens **10** enter the opening c of the pixel **51**R for phase difference detection. Furthermore, only a light that passes through the left side of the photographing lens **10** enters the opening c in the pixel **51**R for phase difference detection that is on the middle side of the light receiving surface **53**, and a light that passes through the right side of the photographing lens **10** does not enter the opening c in the pixel **51**R for phase difference detection.

Furthermore, because the opening b of the pixel **51**L for phase difference detection is decentered reversely in the row direction X with respect to the pixel **51**R for phase difference detection, a characteristic of the sensitivity ratio for the pixel **51**L for phase difference detection is the reverse of that of the pixel **51**R for phase difference detection.

Therefore, as illustrated in FIG. **7**, as we go from the left end portion of the light receiving surface **53** to the right end portion, the sensitivity ratio for the pixel **51**L for phase difference detection is lower. Furthermore, we go from the left end portion of the light receiving surface **53** to the right end portion, the sensitivity ratio for the pixel **51**R for phase difference detection is higher.

Moreover, because a component in the row direction X, of an incident light enters almost vertically the vicinity of the middle portion (a portion that overlaps a straight line which passes through a point that intersects the light receiving surface **53** and the optical axis of the photographing lens **10** and which extends in the column direction Y) in the row direction X, of the light receiving surface **53**, the sensitivity ratio for the pixel **51**L for phase difference detection and the sensitivity ratio for the pixel **51**R for phase difference detection are almost the same.

In this manner, the solid-state imaging element **5** that is equipped with the pixel **51**R for phase difference detection and the pixel **51**L for phase difference detection has a characteristic of the sensitivity ratio as illustrated in FIG. **7**.

The sensitivity ratio for each of the phase difference pairs in an arbitrary horizontal pixel position that is illustrated in FIG. **7** is uniquely determined by an angle of a light beam (hereinafter referred to as an incident light beam angle) that enters the horizontal pixel position. The incident light beam angle will be described below.

FIG. **9** is a diagram illustrating a state where the photographing lens **10** and the solid-state imaging element **5** face toward the column direction Y that is a direction which intersects the optical axis of the photographing lens **10** and the row direction X.

A light that enters an arbitrary horizontal pixel position in the solid-state imaging element **5** includes a principal light beam that passes through the center of the photographing lens **10**, an upper light beam that passes through an upper end portion in FIG. **9**, of the photographing lens **10**, and a lower light beam that passes through a lower end portion in FIG. **9**, of the photographing lens **10**.

The upper light beam refers to a light beam that passes through one end portion (the upper end portion) in the row direction X, of the photographing lens **10** and reaches the arbitrary horizontal pixel position. The lower light beam refers to a light beam that passes through the other end portion (the lower end portion) in the row direction X, of the photographing lens **10**, and that reaches the arbitrary horizontal pixel position.

As illustrated in FIG. **9**, an angle (an upper light beam angle) that the upper light beam makes with respect to an optical axis K of the photographing lens **10** is defined as θ_{upper}, an angle (a lower light beam angle) that the lower light beam makes with the optical axis K of the photographing lens **10** is defined as θ_{lower}, and an incident light beam angle in an arbitrary horizontal pixel position in the solid-state imaging element **5** is defined as a combination of the upper light beam angle θ and the lower light beam angle θ_{lower}.

Even if the horizontal pixel positions are the same, when optical conditions (for example, a combination of an F value, a focal point distance, and a focal lens) changes, the incident light beam angle in the horizontal pixel position also changes.

Each of the sensitivity ratio for the pixel **51**R for phase difference detection and the sensitivity ratio for the pixel **51**L for phase difference detection has a linear characteristic as illustrated in FIG. **7**. For this reason, if the sensitivity ratio for the pixel **51**R for phase difference detection and the sensitivity ratio for the pixel **51**L for phase difference detection in at least two positions in the row direction X, in the solid-state imaging element **5**, are understood, the sensitivity ratio for the pixel **51**R for phase difference detection and the sensitivity ratio for the pixel **51**L for phase difference detection in all positions in the row direction X can be obtained with linear interpolation.

The sensitivity ratio for each of the phase difference pairs that is present in an arbitrary horizontal pixel position is determined by the incident light beam angle in the horizontal pixel position. Furthermore, the incident light beam angle in an arbitrary horizontal pixel position differs with a type of the lens device **100** or an optical condition that is set to be in the lens device **100**.

Accordingly, according to the present embodiment, in a case where the lens device **100** is mounted on the camera main body **200**, information on the incident light beam angle in at least two arbitrary positions in the row direction X, in the solid-state imaging element **5** is obtained for every optical condition of the lens device **100**, and then is stored in the memory **3** of the lens device **100**.

Furthermore, a table in which the sensitivity ratio of each of the phase difference pairs that are present in an arbitrary horizontal pixel position is associated with every incident light beam angle that differs with the arbitrary horizontal position is stored in the memory **16** of the camera main body **200**. Moreover, when a combination of the lens device and the imaging element differs, the sensitivity ratio also differs. For this reason, it is desirable that data on the sensitivity ratio with respect to the incident light beam angle is stored in a device in which an imaging element is mounted, and because the information on the incident light beam angle is determined by a lens, it is desirable that the information on the incident light beam angle is stored in the lens device.

The information on the incident light beam angle that is stored in the memory **60**, and the data in the table that is stored in the main memory **16** can be obtained with actual measurement during an adjustment process before shipment of the lens device **100** or the camera main body **200**.

For example, the incident light beam angle in each of the horizontal pixel positions x**1**, x**2**, x**3**, and x**4** that are illustrated in FIG. **7** is measured for all optical conditions (**1**, **2**, **3**, . . .) that can be set in the lens device **100**, a table as illustrated in FIG. **10** is created from a result of the measurement, and the created table is stored in the memory **60** of the lens device **100**.

Furthermore, for all combinations in which the upper light beam angle and the lower light beam angle are considered, a sensitivity ratio for an arbitrary pixel **51**R for phase difference detection and a sensitivity ratio for an arbitrary pixel **51**L for phase difference detection that are the same in the horizontal pixel position are measured, a table as illustrated in FIG. **11** is created from a result of the measurement, and the created table is stored in the memory **16** of the camera main body **200**. In FIG. **11**, the sensitivity ratios for the pixel **51**R for phase difference detection are indicated by R**1**, R**2**, and R**3**, and the sensitivity ratios for the pixel **51**L for phase difference detection are indicated by L**1**, L**2**, and L**3**.

The light beam angle information that is stored in the memory **60** of the lens device **100** and the table that is stored in the main memory **16** are compared, and thus information on a sensitivity ratio for each pixel **51** for phase difference detection can be known for every imaging condition. In order for the sensitivity ratio to be set to 1, a value by which the output signal of the pixel **51** for phase difference detection has to be multiplied can be obtained as a correction gain value. In this manner, the correction gain value generation unit **176** generates the correction gain value for every pixel **51** for phase difference detection, using the light beam angle information that is stored in the memory **60** of the lens device **100** and the table that is stored in the main memory **16**.

Moreover, as the table that is illustrated in FIG. **11**, the correction gain value for setting the sensitivity ratio to "1" may be stored instead of the sensitivity ratio.

FIG. **12** is a flowchart for describing operation of the digital signal processing unit **17** that is illustrated in FIG. **5**. The flowchart that is illustrated in FIG. **12** results from adding Step S**10** and Step S**11** to the flowchart that is illustrated in FIG. **4**. In FIG. **12**, the same processing operations as those in FIG. **4** are given the same reference numerals and descriptions thereof are omitted.

When a result of the determination in Step S**3** is No, the correction gain value generation unit **176** determines whether or not the light beam angle information is included in the lens information (Step S**10**). In a case where the light beam angle information is not included in the lens information, processing in Step S**5** is performed by the correction method selection unit **174**.

In a case where the light beam angle information is not included in the lens information, the correction gain value generation unit **176** generates the correction gain value that corresponds to each pixel **51** for phase difference detection, for every imaging condition, using the light beam angle information and the table that is illustrated in FIG. **11**, and stores a group of generated correction gain value in the main memory **16**, in a state of being associated with the lens ID that is included in the lens information (Step S**11**). The group of the correction gain value may be stored in the memory **60** of the lens device **100**, in a state of being associated with the lens ID.

Subsequent to Step S**11**, processing in Step S**4** is performed by the correction method selection unit **174**.

As described above, according to the digital camera in the modification example, even in a case where the correction gain value that corresponds to the lens ID is not stored in the camera main body **200** or the lens device **100**, if the light beam angle information is included in the lens information, the correction gain value can be generated from the beam angle information, and then the generated correction gain value can be stored. For this reason, there is no need to store in advance the correction gain value for every imaging condition in the camera main body **200**. Thus, the cost of manufacturing the digital camera can be reduced.

Furthermore, according to the digital camera in the modification example, because the generated correction gain value is stored in a state of being associated with the lens ID, in the lens device **100** in which the correction gain value is generated one time, the generation of the correction gain value can be omitted thereafter. Thus, a reduction in photographing time can be achieved.

Furthermore, in a case where the correction gain value is not stored in any of camera main body **200** and the lens device **100**, and the lens device **100** in which the light beam angle information is not stored is mounted, correction of the output signal of the pixel **51** for phase difference detection is performed with interpolation correction processing. For this reason, in all the lens devices **100**, imaging-obtained image quality can be made to be high or the like.

Moreover, in Step **4** in FIGS. **4** and **12**, the second correction method in which the output signals of all the pixels **51** for phase difference detection are corrected with the gain correction processing is set to be selected. However, instead of the second correction method, a third correction method in which the output signal of each pixel for phase difference detection in the imaging-obtained image signal is corrected by any of the interpolation correction processing unit **172** and the gain correction processing unit **171** may be set to be selected.

There exist scenes for which the interpolation correction processing and the gain correction processing are excellent, respectively. For example, in a case where the output signal of the pixel for phase difference detection reaches a saturation level (blown-out highlight) or has an excessively low value (blocked-up shadow), when the interpolation correction processing is performed, high correction precision is achieved.

For this reason, for every pixel **51** for phase difference detection, it is determined which of the interpolation correction processing and the gain correction processing achieves higher correction precision, and the processing that achieves higher correction precision is set to be performed. Thus, the imaging-obtained image quality can be improved.

For example, as the third correction method, a method is employed in which, as disclosed in JP-A-2012-4729, an edge of an image of a photographic subject is detected and image data is corrected by switching between the interpolation correction processing and the gain correction processing according to the amount of edge. The third correction method is not limited to this, and a method of using the interpolation correction processing and the gain correction processing together may be employed.

So far, a way of selecting the correction method according to the lens information that is stored in the lens device **100** in a lens-interchangeable digital camera has been described.

In addition to this, in the lens-interchangeable digital camera, a way of always performing the interpolation correction processing may be set to be employed without performing the gain correction processing. In this case, it is also possible to support all lens devices. Furthermore, a job of generating a correction gain value is unnecessary.

Furthermore, so far, a description has been provided on the assumption that the camera main body **200** can acquire the lens information from the lens device **100**. However, in some cases, communication cannot be performed between the lens device **100** and the camera main body **200**. For example, in some cases, a genuine mount adapter that is manufactured by the maker of the camera main body **200** in compliance with specifications of lens that is manufactured by another maker is mounted on the camera main body **200**, and a lens that is manufactured by another maker is mounted on the genuine mount adapter.

In such a case, when detecting that the genuine mount adapter is mounted on the electric contact point **9**, the system control unit **11** of the camera main body **200** makes it possible to activate a lensless release mode in which photographing is possible without a lens device. The lensless release mode may be manually set in such a manner that the lensless release mode can be activated or inactivated. When the lensless release mode is set to be employed, it is possible to manually input information such as a focal point distance of a lens.

In this manner, the activation of the lensless release mode leads to a state where the lens information cannot be acquired from the lens device **100** that is mounted on the camera main body **200**. For this reason, in a case where it is determined that the lens information cannot be acquired, the system control unit **11** always performs the interpolation correction processing without performing the gain correction processing. By doing this, even in a case where the lens device that cannot perform communication is mounted, the correction of the output signal of the pixel for phase difference detection can be performed.

Next, a configuration of a smartphone as an imaging device is described.

FIG. **13** illustrates an external appearance of smartphone **300** according to one embodiment of the present invention. The smartphone **300** that is illustrated in FIG. **13** has a flat plate-shaped case **201**, and includes a display input unit **204** into which a display panel **202** as a display unit on one surface of the case **201** and an operation panel **203** as an input unit are integrally combined. Furthermore, such a case **201** includes a speaker **205**, a microphone **206**, an operation unit **207**, and a camera unit **208**. Moreover, a configuration of the case **201** is not limited to this. For example, a configuration can be employed in which a display unit and an input unit are independent of each other. A configuration can be employed in which a foldable structure or a slidable structure is available.

FIG. **14** is a block diagram illustrating a configuration of the smartphone **300** that is illustrated in FIG. **13**. As illustrated in FIG. **13**, a wireless communication unit **210**, the display input unit **204**, a telephone call unit **211**, the operation unit **207**, the camera unit **208**, a storage unit **212**, an external input and output unit **213**, a global positioning system (GPS) reception unit **214**, a motion sensing unit **215**, a power source unit **216** and a main control unit **220** are included as main constituent elements of the smartphone. Furthermore, a wireless communication function, in which a mobile wireless communication is performed through a base station device BS whose illustration is omitted and a mobile communication network NW, of which an illustration is omitted, provided as a main function of the smartphone **300**.

According to an instruction of the main control unit **220**, the wireless communication unit **210** performs wireless communication with the base station device BS that is accommodated in the mobile communication network NW. Using this wireless communication, transmission and reception of various pieces of file data, such as voice data and image data, electronic mail data, and the like, or transmission and reception of Web data, streaming data, and the like is performed.

The display input unit **204** is a so-called touch panel on which an image (a static image or a moving image) or text information, or the like is displayed under the control of the main control unit **220** in order to transfer visually information to a user, and includes the display panel **202** and the operation panel **203**.

For the display panel **202**, a liquid crystal display (LCD), an organic electro-luminescence display (OELD), or the like is used as a display device.

The operation panel **203** is a device on which an image displayed on a display surface of the display panel **202** is arranged in place in a visually recognizable manner, and which detects one set of coordinates or multiple sets of coordinates that result from an operation that is performed with a user's finger or a stylus. When the device is operated with the user' finger or the stylus, a detection signal that occurs due to the operation is output to the main control unit **220**. Subsequently, based on the received detection signal, the main control unit **220** detects an operation position (coordinates) on the display panel **202**.

As illustrated in FIG. **13**, the display panel **202** of and the operation panel **203** of the smartphone **300** that is illustrated as a photographing device according to one embodiment of the present invention are integrated into one piece and thus constitutes the display input unit **204**, and the operation panel **203** is arranged in such a manner as to cover the display panel **202** completely.

In a case where this arrangement is employed, the operation panel **203** may have a function of detecting a user operation on areas other than the display panel **202** as well. In other words, the operation panel **203** may include a detection area (hereinafter referred to as a display area) for a superimposition part that overlaps the display panel **202**, and a detection area (hereinafter referred to as a non-display area) for a part other than the superimposition part, that is, an edge part that does not overlap the display panel **202**.

Moreover, a size of the display area and a size of the display panel **202** may be completely consistent with each other, but both of the sizes are not necessarily consistent with each other. Furthermore, the operation panel **203** may include two responsive areas, that is, the edge part and an inner part other than the edge part. Still more, the width of the edge part is suitably designed according to the size of the case **201** and the like. Still more, as examples of a position detection type that is employed for the operation panel **203**, there are a matrix switch type, a resistive film type, a surface acoustic wave type, an infrared type, an electromagnetic induction type, an electrostatic capacitance type, and the like, and any of them can be employed.

The telephone call unit **211** includes the speaker **205** or the microphone **206**. The telephone call unit **211** converts a user voice that is input through the microphone **206** into voice data that can be processed in the main control unit **220**, and then output the resulting voice data to the main control unit **220**, or decodes voice data that is received by the wireless communication unit **210** or the external input and output unit **213**, and then causes the resulting voice data to be output from the speaker **205**. Furthermore, as illustrated in FIG. **13**, for example, the speaker **205** can be mounted on the same surface as the surface on which the display input unit **204** is provided, and the microphone **206** can be mounted on a lateral face of the case **201**.

The operation unit **207** is a hardware key that is a key switch or the like, and receives an instruction from the user. For example, as illustrated in FIG. **13**, the operation unit **207** is a push-button type switch that is mounted on a lateral face of the case **201** of the smartphone **300**. The push-button type, when pushed down with a finger and the like, is in an ON state, and, when the finger is released, is in an OFF state due to restoring force of a spring or the like.

Control program or control data for the main control unit **220**, application software, address data with which a name of or a telephone number of a communication partner or the like is associated, electronic mail data that is transmitted and received, Web data that is downloaded by a Web browsing, or content data that is downloaded is stored in the storage unit **212**. Furthermore, streaming data or the like is temporarily stored in the storage unit **212**. Furthermore, the storage unit **212** is configured from an internal storage unit **217** that is built into the smartphone and an external storage unit **218** that has a memory slot that can be detachably attached. Moreover, each of the internal storage unit **217** and the external storage unit **218** that constitute the storage unit **212** is realized as a storage medium, such as a flash memory type, a hard disk type, a multimedia card micro type, a card type memory (for example, MicroSD (a registered trademark) memory, or the like), a random access memory (RAM), or a read only memory (ROM).

The external input and output unit **213** is connected to the smartphone **300**, and plays a role of an interface with all external devices. The external input and output unit **213** is directly or indirectly connected with other external devices through communication (for example, a universal serial bus (BUS), IEEE 1394, or the like) or the like, or through a network (for example, the Internet, a wireless LAN, Bluetooth (a registered trademark), radio frequency identification (RFID), Infrared Data Association: IrDa (a registered trademark), Ultra Wideband (UWB) (a registered trademark), ZigBee (a registered trademark) or the like).

As the external devices that are connected to the smartphone **300**, for example, there are a wire/wireless headset, a wire/wireless external battery charger, a wire/wireless data port, a memory card or Subscriber Identity Module Card (SIM)/User Identity Module (UIM) card that is connected through a card socket, an external audio • video device that is connected through an audio • video input/output (I/O) terminal, an external audio • video device that is connected in a wireless manner, a smartphone that is connected in a wire/wireless manner, a personal computer that is connected in a wire/wireless manner, a PDA that is connected in a wire/wireless manner, a personal computer that is connected in a wire/wireless manner, and an earphone. Through the external input and output unit **213**, data that is transferred from these external devices can be transferred to each constituent element within the smartphone **300**, or data within the smartphone **300** can be transferred to the external devices.

According to an instruction from the main control unit **220**, the GPS reception unit **214** receives a GPS signal that is transmitted from GPS satellites ST**1** to STn, performs positioning computing-operation processing that is based on multiple GPS signals that are received, and detects a position that is configured from a latitude, a longitude, and an altitude of the smartphone **300**. When positional information can be acquired from the wireless communication unit **210** or the external input and output unit **213** (for example, a wireless LAN), the GPS reception unit **214** can detect a position using the positional information.

The motion sensing unit **215**, for example, includes a triaxial acceleration sensor and the like, and detects a physical movement of the smartphone **300** according to an instruction of the main control unit **220**. A direction of the movement of the smartphone **300** or acceleration of the smartphone **300** is detected by detecting the physical movement of the smartphone **300**. A result of the detection is output to the main control unit **220**.

According to an instruction of the main control unit **220**, the power source unit **216** supplies electric energy that is stored in a battery (not illustrated) to each unit of the smartphone **300**.

The main control unit **220** includes a microprocessor, operates according to a control program or control data that is stored in the storage unit **212**, and integrally controls each unit of the smartphone **300**. Furthermore, in order to perform voice communication or data communication through the wireless communication unit **210**, the main control unit **220** has a mobile communication control function of controlling each unit of a communication system and an application processing function.

The application processing function is realized by the main control unit **220** operating according to application software that is stored in the storage unit **212**. As the application processing functions, for example, there are an infra communication function of controlling the external input and output unit **213** to perform data communication with a device that faces the smartphone **300**, an electronic mail function of performing transmission and reception of an electronic mail, and a Web browsing function of browsing through Web pages.

Furthermore, the main control unit **220** has an image processing function of displaying an image on the display input unit **204** based on image data (a static image or a moving image) such as received data or streaming data that is downloaded and of doing a job like this. The image processing function refers to a function in which the main control unit **220** decodes the image data, performs image processing on a result of the decoding, and displays an image on the display input unit **204**.

Still more, the main control unit **220** performs display control of the display panel **202**, and operation detection control that detects a user operation that is performed through the operation unit **207** and the operation panel **203**. By performing the display control, the main control unit **220** displays an icon for activating application software, or a software key such as a scroll bar, or displays a window for creating an electronic mail. Moreover, the scroll bar refers to a software key for receiving an instruction to move a displayed part of the image or the like that is too large to fit into a display area of the display panel **202**.

Furthermore, by performing the operation detection control, the main control unit **220** detects the user operation that is performed through the operation unit **207**, enables an operation to be applied to the icon through the operation panel **203**, enables a string of letters to be input into an input box on the window through the operation panel **203**, or receives a request to scroll through a displayed image, which is made through a scroll bar.

Still more, by performing the operation detection control, the main control unit **220** determines whether a position of an operation that is applied to the operation panel **203** is a superimposition part (a display area) that overlaps the display panel **202** or is a part other than the superimposition part, that is, an edge part (a non-display area) that does not overlap the display panel **202**, and includes a touch panel control function of controlling a responsive area of the operation panel **203** or a display position of a software key.

Furthermore, the main control unit **220** can detect a gesture operation that is applied to the operation panel **203** is detected, and can perform a function that is set in advance according to the detected gesture operation. The gesture operation means an operation that draws a track with a finger and the like, designates multiple positions at the same time, or draws at least one track from the multiple positions by combining these actions, not a simple touch operation in the related art.

The camera unit **208** is configured from components other than the external memory control unit **20**, the recording medium **21**, the display control unit **22**, the display unit **23**, and the operation unit **14** in the digital camera that is illustrated in FIG. **1**. The imaging-obtained image data that is generated by the camera unit **208** can be recorded in the storage unit **212**, or can be output through the input and output unit **213** or the wireless communication unit **210**. As illustrated in FIG. **13**, in the smartphone **300**, the camera unit **208** is mounted on the same surface as the display input unit **204**. However, the position on which the camera unit **208** is mounted is not limited to this, and the camera unit **208** may be mounted on a rear surface of the display input unit **204**.

Furthermore, the camera unit **208** can be used for each function of the smartphone **300**. For example, an image that is acquired in the camera unit **208** can be displayed on the display panel **202**, or an image that is acquired in the camera unit **208** can be used with one operation input that is applied to the operation panel **203**. Furthermore, when the GPS reception unit **214** detects a position, the position can be detected by referring to an image from the camera unit **208**. Still more, referring to the image from the camera unit **208**, the optical axis direction of the camera unit **208** of the smartphone **300** can be determined or a current usage environment can be determined without using the triaxial acceleration sensor, or using the triaxial acceleration sensor together. Of course, the image from the camera unit **208** can be used within application software.

In addition, positional information that is acquired by the GPS reception unit **214**, voice information (which may be text information that results from the main control device and the like performing voice-to-text conversion) that is acquired by the microphone **206**, gesture information that is acquired by the motion sensing unit **215**, and the like can be recorded in a recording unit **212**, in a state of being added to image data on a static image or a moving image, and can be output through the input and output unit **213** or the wireless communication unit **210**.

In the smartphone **300** as illustrated above, the solid-state imaging element **5** is used as an imaging element of the camera unit **208**, and thus high-precision phase difference AF and high-quality photographing are possible.

A program for causing a computer to perform a functional block of the digital signal processing unit **17** is deliverable through a network such as the Internet, and thus the program is installed on the smartphone and the like that is equipped with a camera. As a result, the same function as performed by the digital camera that is illustrated in FIG. **1** can be realized. Furthermore, the program can be provided in a state of being recorded on a non-temporary computer-readable medium.

As described above, the following matters are disclosed in the present specification.

The disclosed imaging apparatus is an imaging device to which a lens device is capable of being detachably mounted, comprising: an imaging element that includes multiple pixels for imaging arranged into a two-dimensional array and multiple pixels for phase difference detection on a light receiving surface and that images a photographic subject through the lens device; a communication unit for performing communication with the mounted lens device; a lens information acquisition unit that acquires lens information that is information specific to the lens device, from the lens device through the communication unit; a gain correction processing unit that performs gain correction processing which corrects an output signal of the pixel for phase difference detection in an imaging-obtained image signal that is obtained by the imaging element imaging the photographic subject, by multiplying the output signal by a gain value; an interpolation correction processing unit that performs interpolation correction processing which corrects the output signal of the pixel for phase difference detection in the imaging-obtained image signal by replacing the output signal with a signal that is generated using an output signal of the pixel for imaging that is in the vicinity of the pixel for phase difference detection and that detects the same color as the pixel for phase difference detection; a correction method selection unit that selects according to the lens information that is acquired by the lens information acquisition unit, any of a first correction method in which the output signals of all the pixels for phase difference detection in the imaging-obtained image signal are corrected by the interpolation correction processing unit, a second correction method in which the output signals of all the pixels for phase difference detection in the imaging-obtained image signal are corrected by the gain correction processing unit, and a third correction method in which the output signal of each pixel for phase difference detection in the imaging-obtained image signal is corrected by any of the interpolation correction processing unit and the gain correction processing unit; and an image processing unit that corrects the output signal of the pixel for phase difference detection in the imaging-obtained image signal, using the method that is selected by the correction method selection unit.

In the disclosed imaging apparatus, in a case where the gain value that corresponds to identification information for identifying the lens device, which is included in the lens information, is not stored in any of the imaging device and the lens device, the correction method selection unit selects the first correction method.

In the disclosed imaging apparatus, in a case where information necessary for generating the gain value that is determined by combining the mounted lens device and the imaging element is not included in the lens information, the correction method selection unit selects the first correction method.

In the disclosed imaging apparatus, the information necessary for acquiring the gain value is light beam angle information of the lens device.

The disclosed imaging apparatus further comprises: a correction gain value generation unit that generates the gain value using the information relating to the light beam angle and information relating to sensitivity of the imaging element for every light beam angle, in a case where the information relating to the light beam angle is included in the lens information.

The disclosed signal processing method is signal processing method for use in an imaging device to which a lens device is capable of being detachably mounted, the imaging device including an imaging element that includes multiple pixels for imaging arranged into a two-dimensional array and multiple pixels for phase difference detection on a light receiving surface and that images a photographic subject through the lens device, and a communication unit for performing communication with the mounted lens device, the signal processing method comprising: a lens information acquisition step of acquiring lens information that is information specific to the lens device, from the lens device through the communication unit; a correction method selection step of selecting according to the lens information that is acquired by the lens information acquisition step, any of a first correction method in which the output signals of all the pixels for phase difference detection in the imaging-obtained image signal are corrected by interpolation correction processing that replaces the output signals with signals that are generated using an output signal of the pixel for imaging that is in the vicinity of the pixel for phase difference detection and that detects the same color as the pixel for phase difference detection, a second correction method in which the output signals of all the pixels for phase difference detection in the imaging-obtained image signal are corrected by the gain correction processing that corrects the output signals by multiplying the output signals by a gain value, and a third correction method in which the output signal of each pixel for phase difference detection in the imaging-obtained image signal is corrected by any of the interpolation correction processing and the gain correction processing; and an image processing step of correcting the output signal of the pixel for phase difference detection in the imaging-obtained image signal, using the method that is selected in the correction method selection step.

The disclosed signal processing program is a program for causing a computer to perform each step of the signal processing method according to claim **6**.

INDUSTRIAL APPLICABILITY

The present invention applies particularly to a digital camera and the like, and thus great convenience and high effectiveness are achieved.

The specific embodiments of the present invention are described above, but the present invention is not limited to the embodiments described above. Various amendments are possible within the scope that does not depart from the disclosed technological idea behind the present invention.

The present application claims the benefit of earlier filing date and right of priority to Japanese Application No. 2013-50238, filed on Mar. 13, 2013, the contents of which are incorporated by reference herein in its entirety.

REFERENCE SIGNS LIST

100 LENS DEVICE
200 CAMERA MAIN BODY
5 SOLID-STATE IMAGING DEVICE
9 ELECTRIC CONTACT POINT
10 PHOTOGRAPHING LENS
11 SYSTEM CONTROL UNIT
17 DIGITAL SIGNAL PROCESSING UNIT
50 LENS CONTROL UNIT
51R, **51**L PIXEL FOR PHASE DIFFERENCE DETECTION
60 MEMORY
70 ELECTRIC CONTACT POINT
171 GAIN CORRECTION PROCESSING UNIT
172 INTERPOLATION CORRECTION PROCESSING UNIT
173 LENS INFORMATION ACQUISITION UNIT
174 CORRECTION METHOD SELECTION UNIT
175 IMAGING PROCESSING UNIT
176 CORRECTION GAIN VALUE GENERATION UNIT

The invention claimed is:

1. An imaging device to which a lens device is detachably mounted, comprising:

an imaging element that includes multiple pixels for imaging arranged into a two-dimensional array and multiple pixels for phase difference detection on a light receiving surface and that images a photographic subject through the lens device;

a communication unit that performs communication with the mounted lens device;

a lens information acquisition unit that acquires lens information that is information specific to the lens device, from the lens device through the communication unit;

a gain correction processing unit that performs gain correction processing which corrects an output signal of the pixel for phase difference detection in an imaging-obtained image signal that is obtained by the imaging element imaging the photographic subject, by multiplying the output signal by a gain value;

an interpolation correction processing unit that performs interpolation correction processing which corrects the output signal of the pixel for phase difference detection in the imaging-obtained image signal by replacing the output signal with a signal that is generated using an output signal of the pixel for imaging that is in the vicinity of the pixel for phase difference detection and that detects the same color as the pixel for phase difference detection;

a correction method selection unit that selects, according to the lens information that is acquired by the lens information acquisition unit, any of a first correction method in which the output signals of all the pixels for phase difference detection in the imaging-obtained image signal are corrected by the interpolation correction processing unit, and a second correction method in which the output signals of all the pixels for phase difference detection in the imaging-obtained image signal are corrected by the gain correction processing unit; and

an image processing unit that corrects the output signal of the pixel for phase difference detection in the imaging-obtained image signal, using the method that is selected by the correction method selection unit.

2. The imaging device according to claim **1**, wherein, when the gain value that corresponds to identification information for identifying the lens device, which is included in the lens information, is not stored in any of the imaging device and the lens device, the correction method selection unit selects the first correction method.

3. The imaging device according to claim **1**, wherein, when information necessary for generating the gain value that is determined by combining the mounted lens device and the imaging element is not included in the lens information, the correction method selection unit selects the first correction method.

4. The imaging device according to claim **3**, wherein the information necessary for generating the gain value is light beam angle information of the lens device.

5. The imaging device according to claim **4**, further comprising:

a correction gain value generation unit that generates the gain value using the light beam angle information and information relating to sensitivity of the imaging element for every light beam angle, when the light beam angle information is included in the lens information.

6. A signal processing method for an imaging device to which a lens device is detachably mounted, the imaging device including an imaging element that includes multiple pixels for imaging arranged into a two-dimensional array and multiple pixels for phase difference detection on a light receiving surface and that images a photographic subject through the lens device, and a communication unit that performs communication with the mounted lens device, the signal processing method comprising:

a lens information acquisition step of acquiring lens information that is information specific to the lens device, from the lens device through the communication unit;

a correction method selection step of according to the lens information that is acquired by the lens information acquisition step, any of a first correction method in which the output signals of all the pixels for phase difference detection in the imaging-obtained image signal are corrected by interpolation correction processing that replaces the output signals with signals that are generated using an output signal of the pixel for imaging that is in the vicinity of the pixel for phase difference detection and that detects the same color as the pixel for phase difference detection, and a second correction method in which the output signals of all the pixels for phase difference detection in the imaging-obtained image signal are corrected by the gain correction processing that corrects the output signals by multiplying the output signals by a gain value; and

an image processing step of correcting the output signal of the pixel for phase difference detection in the imaging-obtained image signal, using the method that is selected in the correction method selection step.

7. A non-transitory computer-readable medium storing a program for causing a computer to perform each step of the signal processing method according to claim **6**.

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